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# CALIFORNIA

# CITRUS CULTURE

BY

A. J. COOK

State Commissioner of Horticulture

FRIEND WM. RICHARDSON, SUPERINTENDENT OF STATE PRINTING
SACRAMENTO, CALIFORNIA
1913.

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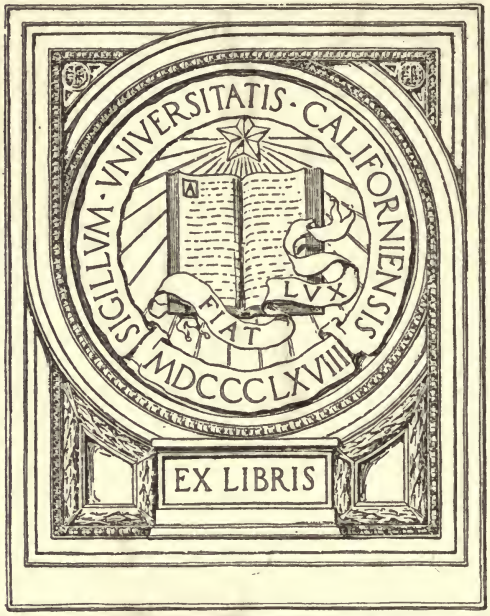
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SACRAMENTO, CALIFORNIA

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# CITRUS CULTURE

BY

A. J. COOK

State Commissioner of Horticulture

UNIV. OF CALIFORNIA

Printed at the State Printing Office, Friend Wm. Richardson, Superintendent.

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# PREFACE.

Since assuming the duties of State Commissioner of Horticulture, October 20, 1911, there have come to this office many requests for literature on citrus culture. We could not meet this desire, as the admirable work of the late Mr. B. M. Lelong, for years connected with this office, has long been out of print. This led to the writing of this little treatise. It seemed wise and well to prepare at once something to take the place of Lelong's "Culture of the Citrus in California" to send out in response to these requests, and hence this unpretentious booklet.

I have purposely made this a manual; simple, brief, and severely practical. We might have gone thoroughly into the history of citrus culture, especially in our State, but the beginner or novice, for whom this is principally intended, usually cares little for that; we might have discussed varieties at length, but this would be confusing and not in accord with our purpose, and so we have considered this subject only so far as it is immediately practical.

I am greatly indebted to Messrs. C. C. Teague, R. M. Teague, A. F. Call, C. C. Chapman, Dr. G. Harold Powell, Fred Reed, J. H. Reed, J. D. Culbertson, E. K. Koethen, R. P. Cundiff, and especially the secretary of the commission, Mr. E. O. Essig, and many others who have given valuable aid.

A. J. COOK.

Sacramento, California, July 1, 1913.

# CALIFORNIA CITRUS CULTURE.

We can not but marvel at the growth of the citrus industry, especially the orange and the lemon, in California during the past two decades. In the early nineties it was a mere infant. We now have nearly two hundred thousand acres, and ship well nigh fifty thousand cars annually, for which almost forty million dollars are received, of which nearly one third is paid to transport the fruit to the markets. The following statistics show graphically this rapidity of growth: In 1891, 4,056 cars were shipped; in 1901, 24,097; in 1911, 46,399. The number of boxes per car is now 396.

The reason for this rapid growth is not far to seek. "A thing of beauty if a joy forever." What can excel in beauty an orange grove loaded with ripened fruit (Fig. 1), or a lemon tree at any time or season? We all love and are ennobled by our environment where loveliness is dominant; and so it follows that citrus fruit growers will be generally marked by refinement and culture. Indeed, the successful citrus orchardist must be a student and must possess rare intelligence. Even the so-called learned professions at their best call for no better thought or deeper study than that required by the highest success in growing and marketing the orange, the lemon and the grapefruit or pomelo. The grower must be a close student of details. The people of highest type enjoy most that which causes them to think and study most, and so our best folk are flocking to citrus culture as affording keenest mental enjoyment and the finest ethical stimulus.

The profits in citrus production are equal to those in any line of agriculture. It is brainy work and nowhere do brains count for more. I have been a close student and observer of citrus orchards and citrus fruit production for nearly twenty years, and have known orchards for all that time that have never missed a crop. Where every detail of care is observed by the orchardist, the trees rarely fail to respond with a good and often a colossal production.

A small orange grove can be cared for by its owner with very slight aid from others, and thus the greatest handicap in agriculture—inability to secure labor—is solved. I have known one man single-handed to care thoroughly well for a ten-acre orange grove, and such a grove will give generous support to its owner. I have known a man to care for forty acres, with no other aid except at time of irrigation and picking. In case pruning is extensive, it would require extra service. One can hardly picture a nearer approach to Utopia than a community

of citrus growers, each with a grove of from five to twenty acres, and each rivalling the other in the care and intelligence of his management. The climate must be genial, for only in such a climate will these fruits thrive. In California, the scenery rivals the best in Switzerland, and the labor, never too arduous, is uniform the entire year through. The free, pure, outdoor air is surety for health and vigor, and a happiness

FIG. 1.—Orange trees at San Gabriel thirty years old. (After Lelong.)

and comfort that ever attends honest endeavor in the field of agriculture, is nowhere more certain than to the owner of a citrus grove that is properly located and well cared for. We can not wonder then that citrus culture has advanced by leaps and bounds, and can safely predict that the future will greatly surpass the past, and even the present, in its growth and production.

## CITRUS FRUIT TARIFF.

There is a tariff of one and one half cents per pound on lemons and one cent per pound on oranges. The one half cent additional on lemons was added in 1910 and has greatly stimulated the planting of lemons. If this protection continues, in a few years sufficient lemons will be planted to supply the entire demand of the United States. This is now true in the case of oranges, which have been protected by a one cent per pound tariff, so that now our country produces all its own oranges.

There is little doubt but that the tariff on both oranges and lemons will be reduced to one half cent by the present extra session of Congress.

# EARLY HISTORY.

In that excellent volume, by the late Mr. B. M. Lelong, "Culture of the Citrus in California," will be found an interesting account of the early development of this industry in our State. It was more than a century and a half ago that the Mission Fathers introduced the orange, the fig, the foreign grapes, and the olive. These padres came to help men to a more abundant life. They did more; they demonstrated that our genial climate made our much prized citrus fruits entirely at home.

California gained its great renown from the discovery of gold. Little did the early miners dream of the riches in the soil while in quest of nuggets in the placers and river gravels or the locked-up gold of the quartz mines. Yet to-day our orchards fairly eclipse the mines in the wealth they pour into the pocketbook of the State. Except for oil, no single product of California begins to compare in importance, measured by the net cash returns, with that of the citrus groves. G. Harold Powell, general manager of the California Fruit Growers' Exchange, than whom no one is more able to give an authentic opinion, states that the "citrus industry represents two hundred million dollars capital invested, ten thousand growers are interested, one hundred thousand people depend upon it for a livelihood, while fifty thousand carloads are expected to be shipped from the State the present season." We see that the citrus product of to-day is a very leading factor in the business interests of the State. There is apparent the urgency of pushing with vigor all that helps to advance this important interest and of working to stay with all possible energy whatever tends to handicap it.

To quote again from the work of the late Mr. B. M. Lelong: "While orange trees were among the first introduced into the State, having been brought by the Mission Fathers, it may be said that orange culture is of very modern origin, and the industry has assumed commercial importance only since 1880." At first it was supposed that only the south was sufficiently balmy to make citrus culture possible. Now we know that in the elevated mesas and the foothill valleys of both the northern coast and Sierra ranges there are favored localities where citrus culture is successfully practiced, as far north as Placer, Glenn and Butte counties. In fact, the fruit in these northern counties is of excellent quality and ripens earlier than in the south. This promises only good to the State, as we shall be able to maintain a market of superior oranges, as we do now of lemons, throughout the entire year, from January to January. This guarantee, that the best

will always be at the command of the purchaser, is of great importance to both the producer and consumer. The northern groves possess two advantages: They supply the early better market, and the early ripened fruit is likely to precede any possible frost.

## LOCALITY.

There are certain requirements that should always engage the most serious and painstaking attention of the one about to engage in the growing of oranges and lemons: soil, water and climate are dominant factors in successful citrus culture.

The soil should be a rich loam; either clay, or sand or gravel may predominate. We now know that humus is an absolute requisite for any productive soil or any crop, so a good supply of organic matter is essential. While in such arid soils as those of California, humus is unfortunately limited in amount, yet the nitrogen content of the humus in these soils is usually large; thus I say, rich loam, for though we may supply this decaying organic matter, when it is meager in quantity, yet the orchardist is most favored who has in his soil a goodly proportion of this valuable humus. We have only to mention Redlands, Riverside, Santa Paula, and Porterville to prove that the best citrus fruit can be produced on quite heavy clay; even adobe soil often produces first-class oranges and lemons; on the other hand, much of the San Gabriel Valley is remarkable for its sandy, gravelly acres. This soil may also boast of great crops of very superior fruit. The clay soils are very strong, very productive, very enduring, but they must be kept aerated and in good tilth, which is no light task. The man who cultivates a clay citrus grove must have good brain power, and must use his brains to the limit. We may say a grove of heavy clay soil is first best if its owner is first best. Such soils must never be tilled when not in prime condition and the drainage should be perfect. A sandy, gravelly soil is less retentive of moisture, is not so strong, and must be abundantly fed. It can be worked almost immediately after a heavy rain with no serious injury, and so may be handled with less of care, less of diligence—in short, less of brains. Such soils suffer little from lack of aeration. I was told, in Sicily, that the lemons grown on clay soils were superior in quality, brought a higher price—one fourth more—and kept better than those grown on sandy soils.

It is also necessary to have a soil that is deep and with a good subsoil. An artificial hardpan from six to eight inches from the surface is not uncommon in any kind of soil. A natural hardpan still deeper down is often found. In purchasing a location for citrus trees, we should never fail to dig down and find out just the condition of the subsoil—the soil just below the plane reached by the plow. King's soil tester makes it easy to learn the character of the subsoil to a depth of five or six feet. Any hardpan is prejudicial to success. It is also very essential to avoid black alkali or carbonate of soda. We have only to keep these points in mind to choose wisely in the purchase of lands for citrus fruits, so far as the soil is concerned.

## WATER.

The purchaser must be even more wary regarding the ability to secure sufficient water for irrigation, as nearly every California soil will, with proper care and cultivation, give remunerative crops. Water is the very life of the grove. No one should ever purchase a grove, or land for a grove, unless he is absolutely sure that abundant water is always at his command. In planting, we must not forget that the older the trees the more water required. The government experts, who have investigated along these lines, caution those who are planting new groves, and state emphatically that in many localities in California, though not in all, we have now reached the limit of safety in planting. In some sections we have, however, come far short of developing the amount of water that may be secured from underground reservoirs by boring wells and pumping. Very much more water will be pumped for irrigation in the near future than is now secured. In a few places reservoirs above the surface may be formed to add to our water resources, and in these the winter run-off may be stored and held for use. It is also demonstrated by actual experience that by wisely distributing the water during the copious rains of winter, what would else go in the winter run-off to the sea, can be stored up in the subearth gravels and be utilized in the long dry season of summer. Yet we may still urge that since water is the great desideratum and the absolute necessity in citrus culture, the securing a full supply for the coming time when the groves are all mature and in full bearing, and for years of least rainfall, should engage the chief and most thorough consideration of him who is contemplating the purchase or planting of citrus orchards. We must also always be cautious that the water we use is free from alkali.

## LOCAL CLIMATIC CONDITIONS.

As regards the liability to frost, we can not be too cautious in selecting a locality for a citrus grove. True, the orange (the lemon is a little more susceptible to frost than is the orange) will resist a temperature a little below freezing, perhaps as low as 26 degrees Fahr. if not too long continued, but if the thermometer goes down to 22 degrees or 25 degrees Fahr. above zero, both fruit and tree are likely to suffer. This is the more true if the cold endures for quite a long period, and if the sun comes out clear the following morning the damage is increased. It is found in California, as elsewhere, that the cold is more pronounced in lower levels, so that it is safer to locate higher up on the mesas. The cold, like water, flows down into the lower valleys, so that often the lower groves will suffer harm, while those higher up escape all damage. It is a gratifying fact that seriously cold seasons do not occur in California on an average oftener than about one year in four.

## FROST PREVENTION.

As a question of permanent public policy, it is uncertain how far protection against frost, by artificial means, may wisely be carried; but where orchards are already planted, it is surely unwise to neglect the insurance that is afforded by a proper equipment for frost protection. The cost will be great, and the labor involved in the fight will be both disagreeable and exhaustive, when the cold nights come. But when not only the fruit but the trees themselves are at stake, the orchardist can not afford to take any chance. In one large lemon grove the expenditure of $6,000 fighting frost in the winter of 1911–12 saved $100,000 worth of fruit. While the year following, when the cold reached a temperature of 15 degrees above zero, it cost twice as much to save the crop. Yet at this time not only the fruit was saved, but irreparable damage to the trees was prevented. Many would have been killed outright, others greatly injured.

Prior to 1911, for years, the coal baskets, one to each tree were successfully used in frost protection. The experience in 1911 proved that oil pots were preferable to coal baskets. Oil as a fuel is more

easily handled and much more economical. This season millions of oil pots are being purchased. The oil pot now desired has a capacity of seven gallons, a down draft tube that insures the entire consumption of fuel oil or cheap distillate and regulation of the flame to greater or less heights as the degree of cold requires. These are costly but the expense is more than warranted. The soot resulting from incomplete combustion smuts fruit, but by washing the latter in warm water containing gold dust after a quick submergence in kerosene oil the smut is wholly removed.

The lessons taught by the unprecedented frosts of January, 1913, are first: We can not count on any frostless region in California. San Diego had never been injured before, but suffered severely last January. The same was true of the foothill mesas along the San Gabriel mountains.

Lemons, both the fruit and trees, are more susceptible than oranges; young trees than old. Apparently trees inured to cold are less likely to be damaged than are others. Severe frosts in Sacramento seemed less injurious to citrus trees than a like frost at Santa Barbara or San Diego.

It was conclusively demonstrated that by the use of oil pots—smudge—the orchards could be absolutely protected. In some orchards which were thoroughly provided with pots and oil the fruit was wholly protected, and the frost was a real advantage, as the high prices are very exceptional and bring great profits to the vigilant orchardist.

While the thick canopy of smoke often resulting from the fire may, and doubtless does, do some good in acting as a blanket to retard radiation, yet it is probable that a smokeless heater which consumes all the carbon would produce more heat and be more advantageous.

While the soot can be easily and cheaply removed from the fruit, yet it is very obnoxious, as it pushes into houses and begrimes tapestry and curtains, and is a very serious inconvenience. It would seem that the ideal pot would be smokeless, one that would consume all the refuse from the oil, leaving the pot clean, would burn crude, or cheap, oil, hold sufficient oil to burn all night, if required, and so made that it can be filled with no spilling of the oil.

There are two methods which are quite satisfactory in determining whether or not the fruit has been frozen. By placing the fruit in diluted alcohol of the right density, which can be easily determined by experiment, the frozen fruit does not sink and so is easily separated from the heavier unfrozen fruit. The other method is by the use of a current of water which separates the injured from the sound fruit on the same principle that gravel is sorted by a running stream. This latter arrangement originated with Mr. Harry Chase of Riverside, and

is reported to give accurate determination. Of course it need not be said that frozen fruit should never be marketed.

Frozen trees should not be pruned until time and new growth show the exact limit of the killing of the branches. Then all dead portions should be removed. In case the cambium, or inner bark, is killed down to or below the bud then the whole of the trunk may be cut away, and new growth from the crown can be permitted to grow, and this may be budded to produce the desired variety of fruit. If branches start above the bud, the largest of these may form a new tree and no further budding will be required. If desired, the trunk can be retained for a time and will serve well to support the new growth. In this case it is well to trim the trunk of all dead limbs, when it will be easy to grow and cultivate beans among the injured trees. These will give a good profit and serve to keep up the fertility of the land.

THE CITRUS GROWER MUST REMEMBER THAT GOOD AND SUFFICIENT OIL POTS ARE A WISE AND PROVIDENT INSURANCE AGAINST LOSS AND POSSIBLE RUIN.

# PLANTING THE ORCHARD.

## PREPARATION OF SOIL.

In preparing to set an orchard the soil should be thoroughly and deeply cultivated, especially if it is a clay soil. We have seen that a rich supply of humus is very essential. If, then, a heavy stand of vetch, alfalfa or sweet clover could be grown and plowed under before planting, in time to become well decomposed, it would aid in making a first-class planting ground. The soil should be moist when the trees are set.

## THE YOUNG TREES.

These should be vigorous, well formed, and wholly free from fungous affection or insect attack. Usually it will be necessary to secure them at a nursery. In such case, a reliable nursery should be sought and a careful inspection of all the trees made by an expert. In case one can do so, it is well to grow his own plants in the seed bed from selected seed. Seeds from sour stock are now thought the best. Trees from these are said to resist fungi and frost, especially when young, better than others. Those from fruit known to be produced on a very vigorous, productive tree are to be preferred. A very productive tree must possess great vitality, and the seed would be likely to partake of this character and produce excellent plants. Even more important

is it to secure the buds of trees that invariably produce more generously of fruit of rare excellence. Such a course would almost certainly result in producing a phenomenal orchard, for it is a well known law of nature that "like produces like." There may be exceptions, but these only prove the rule. (See article by A. D. Shamel in August, 1912, The Monthly Bulletin, California Horticultural Commission.) The trees in transplanting must be dug from the nursery so as to disturb the root system as little as possible. They should be balled, kept moist, and planted out with the least possible delay. In setting, the earth should be firmed about the roots when practicable, by use of water, and if the planting is done in early spring (I have had satisfactory results in planting in February, though most prefer May and June) we are quite sure to have excellent success, if our subsequent care is what it should be. If the earth keeps cold, planting may be deferred even to late summer. It is best to cut back to preserve the balance between roots and top. As this work is so vital to success, I will discuss it more in detail.

## PLANTING THE ORCHARD.

As before stated, the land prior to planting should be thoroughly prepared. This means that it should be deeply and thoroughly cultivated, well enriched by previous cover crops plowed under or by use of stable fertilizer, at least ten big loads to the acre. In a virgin soil manure may be safely deferred for two or three years. The ground should also be leveled and graded to perfection, as this will save immensely in labor and peace of mind in the future care of the orchard. A uniform grade is desirable with a minimum of one per cent fall if possible. We should never grade off the surface soil where contour or change in direction could make it unnecessary. The reason is obvious. The surface soil is usually better supplied with the necessary soil elements. I fear not all will follow this advice, but those who do not will surely realize their mistake later.

## PROCURING THE TREES.

It is wise to see the trees before purchasing, to make certain that they had been grown under proper conditions. One had best purchase some months before planting, as he is more likely to secure good trees. The price usually runs from forty cents to one dollar per tree, varying with size, supply and demand, and number purchased. If possible, one may well buy selected trees, paying more. This is one signal advantage among many of growing one's own trees from seedbed to orchard.

Too much care can not be exercised in removing budded trees from

the nursery and preparing them for shipment. There are two methods: the open-root and the balling. A ditch, eighteen inches deep on one side, eight inches from the row, permits cutting all the roots on that side, and also the tap root or roots. Then for open roots, the tree may be crowded into this trench, breaking as few roots as possible. This is allowable only for near-by planting. A long, sharp spade makes it easy to cut the roots on the other three sides. If we wish to ball, which is best in most all cases, we tamp the soil, shape the ball and lift the tree on to burlap, which is then folded and tied about the trunk. Haste in transportation is always in order. The trees upon arrival at their destination should be heeled-in, pointing southwest, in case of open roots, or planted at once. A furrow with a 45-degree slant on one side makes heeling-in easy. None but the open root trees should be heeled in, and it were always better to set at once. If one grows his own nursery stock, this is the more easily accomplished. No one should order trees until he is ready to set them. From the heeling-in furrow to the orchard, trees should be handled with as little delay as possible, and unless balled should be covered with a wet blanket, especially if the day is hot.

## ARRANGEMENT OF TREES IN ORCHARD.

There are four methods of planting as to arrangement of trees: rectangular, triangular, quincunx or hexagonal. The first, square or rectangular, is simplest and most common. Indeed, it is the almost universal method to-day. If in squares (Fig. 2), the trees are often planted twenty feet apart, which gives one hundred and eight trees to the acre. Most prefer to plant further apart, at least one way. If twenty by twenty-five feet, then we have eighty-seven trees to the acre. It is quite common to have the squares twenty-two by twenty-two feet, which takes ninety trees to the acre. This is quite close enough, and there is wisdom in increasing this. The squares are often twenty-four, twenty-five or twenty-six feet on each side.

In the triangular system (Fig. 3) the trees are parallel to one margin of the field in one direction and diagonal to this the other way. The trees will be further apart on the diagonal lines. Suppose we wish to plant twenty feet apart in the rows parallel to the margin. We then lay off the orchard in twenty-feet squares. The first row will be at the angles of the squares, next to the margin of the field. The trees of the second row will be at the middle points of the opposite sides of the squares, etc. Each alternate row will have trees at the angles, the next at the middle of the sides of the squares. This gives ninety-eight trees to the acre. The trees will be twenty feet apart one way and a little more than twenty-two feet the other way. This has no advantage, except it permits cultivating or working the ground in three directions.

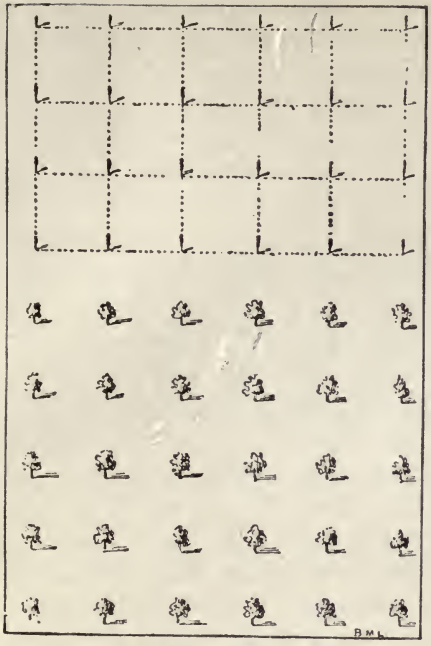

FIG. 2.—The square system. (After Lelong.)

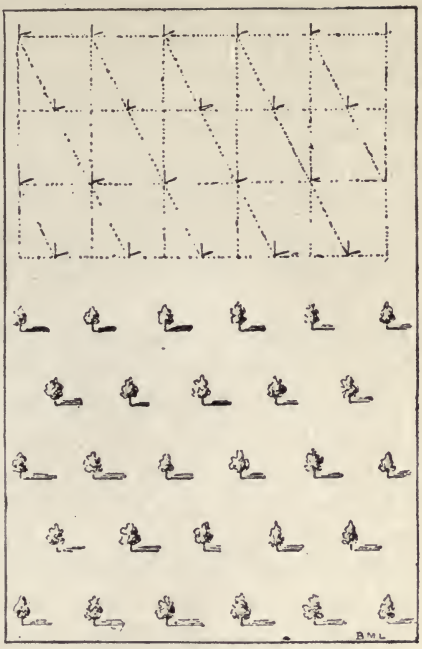

FIG. 3.—The triangular or alternate system. (After Lelong.)

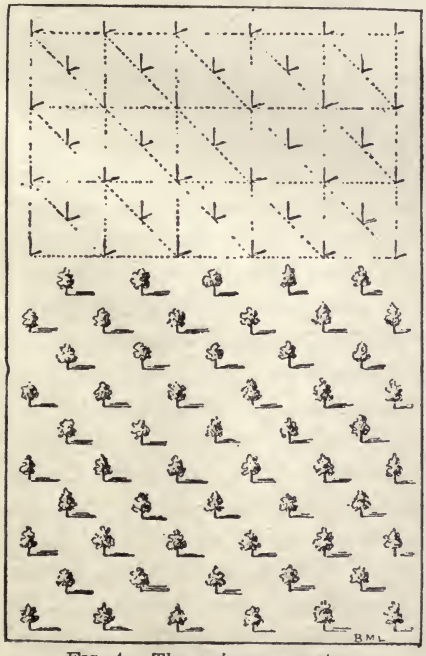

FIG. 4.—The quincunx system. (After Lelong.)

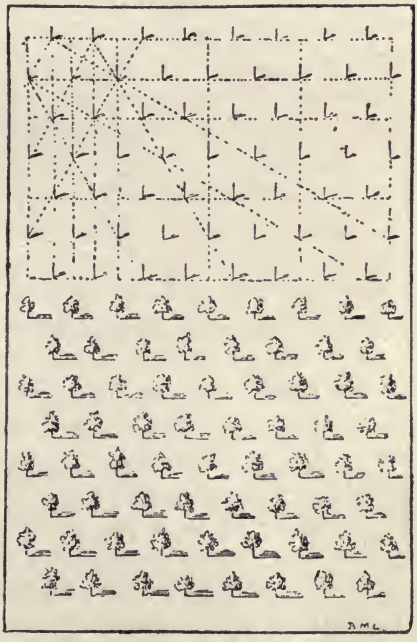

FIG. 5.—The hexagonal system. (After Lelong.)

The quincunx system (Fig. 4) is like the rectangular, except that a tree is planted in the center of each square or rectangle. This adds to the number of trees. If the square is twenty feet on each side, there will be one hundred and ninety-nine trees to the acre. It also serves when more trees are desired in a young orchard, some of which will be removed as the trees age. It makes this removal easy, without affecting the symmetry of the grove.

In the hexagonal or sextuple system (Fig. 5), six trees mark the angles of an equilateral hexagon, with an extra tree in the middle point between them. In case the trees are twenty feet apart, the first row will be parallel to the one side of the field, and the trees twenty feet apart. Two twenty-foot lines stretched from the first two trees of this row towards the opposite side of the field, approximating each other, will fix the location of the center tree where they meet. This will be the first tree of the second row, which will be parallel to the first row. The trees of the third row will be exactly opposite those of the first. Here alone, of all the systems, each tree is equally distant from all adjacent trees. If the trees are set twenty feet apart, then one hundred and twenty-four trees will be set on each acre. Here the trees may be cultivated diagonally in two directions and in a third direction parallel with the side.

## PLANTING THE TREES.

Citrus trees may be planted at almost any time; better from February to August. I prefer February—when the trees are more dormant, though the heaviest plantings are in April and May, and as late as June. This avoids frost, and the trees will respond to the temperate heat of spring.

The holes may best be dug just prior to setting the trees and should be ample in size, not less than two and a half feet in diameter. They should be dug a little deeper than necessary to accommodate the trees, the extra space being filled with fresh, rich fertile soil. The bruised roots of each tree should be cut off diagonally with a clean cut, just above the wound, and the top cut to balance the root pruning and to give all the trees similar and symmetrical heads. Some of our growers leave all the top and foliage intact; others prune the top heavily, removing all the leaves. I think the above course, trimming to balance top and root system, is preferable.

Fig. 6—Young roots separated by hand in planting. (After Lelong.)

As the trees are placed in position, the roots, if the trees are not balled, should be evenly separated (Fig. 6) by hand, and in every case the hole filled three fourths full

with good surface soil, when enough water should be added to settle the soil thoroughly about the roots or ball and to crowd out all the air and saturate the ball through and through, after which fill in to the top, leaving the trees a little higher than they stood in the nursery, as they will settle slightly after they are planted. The bud should be some inches above the earth. Not only should the bud be well above the ground, but it is equally important, probably more important, not to plant the roots too deep. Preferably the crown roots should not be planted more than two inches below the mean surface level of the crown.

As soon as the trees are all set they should receive a thorough irrigation, especially if not balled, and a good cultivation as soon thereafter as the soil is in proper condition, both of which as we have seen should be deep.

## PROPAGATING CITRUS TREES.

More and more, I think, will our citrus growers start their own trees. Yet nurserymen need not shiver at this advice, as few will follow it. The orchardist can then select seeds and buds, and can care for the plants from the very first, and very likely such care, costing but little, will double the annual income as the trees come to maturity. I know starting trees is a complex matter—a trade to be learned, but I have great faith in Yankee gumption.

As large seeds are preferable, seeds of the sour orange, sweet orange and pomelo are to be preferred, the largest seeds always to be selected. These should be secured from the fruit of trees of maximum performance and thrift. Whether or not the stock affects quality of scion or bud so as to influence quality of fruit, surely every plant and animal has better promise if the parents are full of vigor, health and action. In Europe sour stock is everywhere preferred and almost universally used. We are now rapidly coming to the same practice.

Seed are secured by cutting selected fruit, squeezing out pulp and seeds and sieving; or the fruit may be decomposed in water and the seeds washed free from the pulp by use of the sieve. The seeds should never be permitted to dry, and to prevent this they may be stratified in moist sand till needed for planting. Seeds from Florida come dry, but will germinate readily if soaked in water about seventy hours before planting. Mr. R. M. Teague, one of our most successful growers, always plants in the open, with no protection. He thinks this gives him hardier trees and a better root system. It is to be said, however, that his loca-

tion is in a very protected district. But most of our nurserymen protect the young plants by use of a lath cover. The seeds should never be planted until the earth is warm or they may decay. In any case, the soil should be rich, loamy, and with a surface of sand at least for two or three inches. If this is slightly ridged, and the seeds planted on the ridges, the drainage will be more perfect and the damping-off fungus will not be so likely to put in its deadly work.

From March to May, depending upon season and soil, is the time to plant the seed bed. The seeds are best planted in rows one foot apart. The seeds are covered about one inch with soil that has been screened.

FIG. 7.—Young seed bed orange stock. (After Lelong.)

It is easy to irrigate between the rows and to cultivate with a hand cultivator. The seeds will come up in about three weeks if the weather is favorable. The young seedlings should be well watered and cultivated and left in the seed bed for one year. As already stated, many prefer to protect the young seedlings. The earth must be kept moist, but not too wet or the plants will die of fungus attack. The early spring is the best time to plant not only the seeds but to transplant the seedlings.

The young plants from the seed beds (Fig. 7) should be transplanted to the nursery in rows at least three or four feet apart, or so as to

admit of cultivating by horse without injury, and fifteen inches apart in the rows. This gives ample room for digging and balling. The plants are easily loosened in the seed bed by the use of a long spade, and should be quickly set, as the roots must not be permitted to become dry. Only robust plants should be transplanted to the nursery. As Mr. R. M. Teague says, "the best are none too good." Some advise keeping puny plants for two years in the seed beds. It were better to discard them entirely. To take up the seed bed plants, a four or five tined potato fork is excellent. It will not cut the roots as will a spade. If the weather is hot it is well to place shade boards above the young plants. The nursery should be carefully watered and cultivated for two years, when the nursery trees should be ready for budding. This insures larger and stronger trees, and the buds can be set six inches above the ground. Budding is possible whenever the bark slips easily, and may be done in March and April. Summer budding is not uncommon, though the best time to set the buds is in September and October. The buds will start as soon as the sap begins to flow; will become strong before fall and will resist the cold of winter. Here, again, it is well to select only the best of the young trees. The bud union is the weak place in a citrus tree, and should be well above the reach of irrigating water as a preventive of gum disease.

## SELECTING BUDS.

The selection of the buds is, I think, the most important step in the whole range of citrus culture, and is reason enough for one to grow his own trees, at least from the time they are set in the nursery. Only buds from tested trees, whose performance has been most excellent in both quality and quantity for a number of years, should ever be accepted. This gives us pedigreed stock. In this way we hope to double our output and profit. We must remember what selection has done for corn in Illinois and Iowa. (See article on breeding citrus trees, by A. D. Shamel, The Monthly Bulletin, California State Commission of Horticulture, Vol. I, No. 9, August, 1912.)

Mr. R. M. Teague uses only selected buds. He allows his patrons to furnish their own buds if they so prefer, though this privilege is rarely accepted. The past season only two persons accepted the offer, though he sold over two hundred thousand trees. Only plump, vigorous buds should be used. The method of inserting the bud is explained by Figs. 8 and 9, where is shown the T-shaped cut, the peeling of the bark and the cutting and insertion of the bud. The tying by budding twine or waxed strip of cloth is well shown. Some of the twigs with foliage are left on the young plants to promote vigor (Fig. 10), though not many,

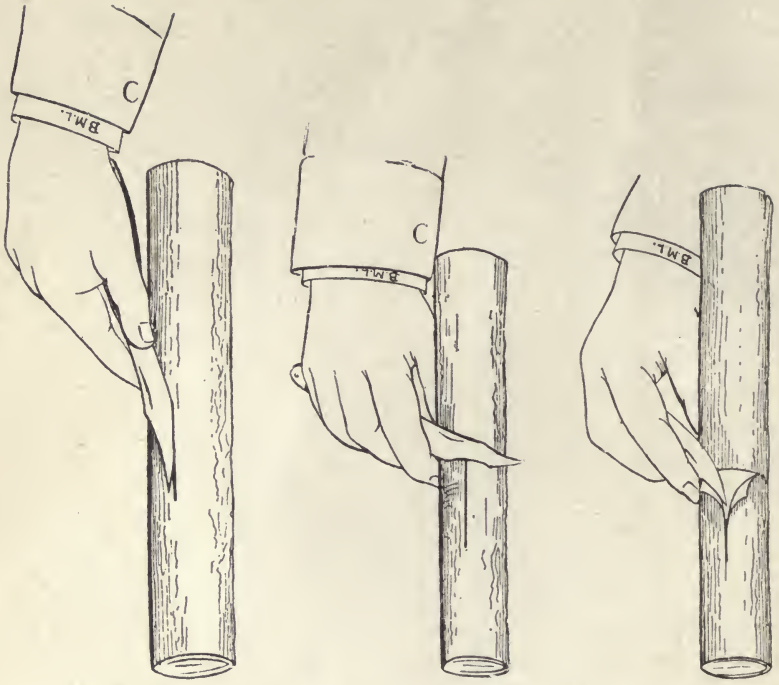


FIG. 8.—Preparing the stock to receive the bud. (After Lelong.)

FIG. 9.—Cutting the bud from the scion. (After Lelong.)

as we wish to throw sap to the buds. After the buds are well started the old twigs may be gradually removed. One or two years after budding the young trees are ready to set in the orchard.

Large trees may be budded if a change of variety or if a better tree is desired. Here the buds are inserted into the branches (Figs. 11 and 12), some of which are permitted to remain to insure thrift, and removed as the new growths from the bud become large and thrifty. The trunks in this case should be protected from the sun's hot rays by whitewash, or by wrapping with some protecting cover. It is also well to protect young trees in the orchard in similar fashion. All pruning

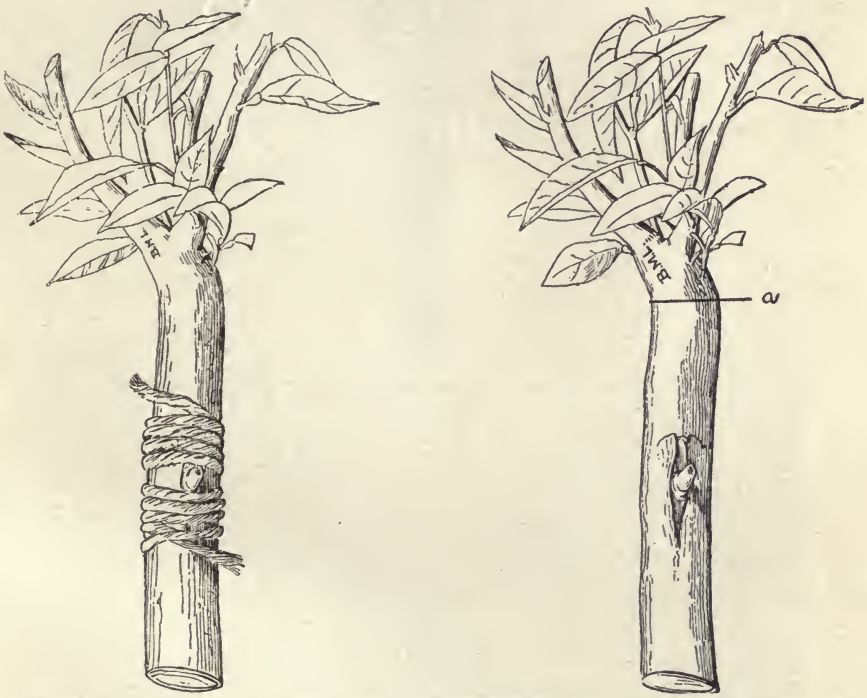


FIG. 10.—Showing bud inserted and the wrappings. In some cases a few limbs are left to promote vigor. (After Lelong.)

of orchards should be close, and the fresh cut at once waxed over. In case Fuller's rose weevil attacks the buds, as they are wont to do, the insects may be headed off by winding loose cotton about the trunk below the bud. The beetles are wingless, and so can reach the buds only by crawling up the trunk. The cotton will prevent this.

Citrus trees can be started by grafting, by slips, or by layering, but as none of these methods are now in vogue in our citrus orchards it is needless to discuss them here.

FIG. 11.—Orange tree cut back to force it to throw out shoots from the main branches, which are budded. The body of the tree is protected with burlap or whitewash. (After Lelong.)

FIG. 12.—Large seedling orange trees worked over by budding in the main branches. (After Lelong.)

# CARE OF THE YOUNG CITRUS ORCHARD.

Humus is very essential to the best growth and vigor of our trees. Therefore, a good application of well-rotted stable fertilizer will be welcomed by the young trees even the first year. The trees must never feel the lack of abundant moisture. At first basins about the trees for irrigating are allowable, but furrows, even in the young orchard, are usually the cheapest and the best. In any case the water should not touch the tree trunks, and the irrigation should be deep, then the roots will go down deeply, where they always should be. We often talk of trees as being deep or shallow rooting, but are not these conditions the results of our special methods? The roots will go where the water or moisture is. The elms in the eastern swamps are very shallow rooting. I have grown them here in California, and found the roots deep in the soil. Surface irrigation invites the roots to the surface, while if the water is placed deep down the roots are impelled to push down to secure it. Shallow rooting trees in an arid soil will always suffer in times of drought; while trees with roots deep in the soil will usually suffer not at all. I have trees that I have set and cared for for

FIG. 13.—Orange trees pruned high. (After Lelong.)

fourteen years, always irrigating in deep basins or furrows, and now, when I plow deeply in fall or spring, the roots are never harmed. In clay ground it is well to plow deeply, and one can do so safely where the roots are beyond harm's way. I repeat, the roots should be kept down, but if, from improper cultivation and irrigation, this has not been done, the wrong may be righted by plowing each succeeding fall and spring a little deeper. Such a course is certainly wise. I urge

again, the first year the trees must never feel the want of water. As with young animals, dwarfed in youth, always dwarfed.

The second season the trees must be pruned to form a head that is shapely, but this pruning should be as light as possible to produce a

FIG. 14.—Orange tree headed low. (Photo by A. D. Shamel.)

symmetrical tree, as the abundant foliage is of signal use at this period. In Italy the trees are headed high (Fig. 13), so that one can walk under the lower limbs. The practice of lower heading (Fig. 14) is much to be preferred. The lower branches should leave the trunk at varying heights to avoid crotches and splitting.

# FERTILIZATION.

In the young orchards—in all orchards—a winter cover crop of vetch, Canadian field peas, burr clover, or other vigorous legumes (vetch is probably the best) is very desirable. This insures against washing of the soil in case of heavy rainfall, supplies the needed humus, and also adds to the soil the most expensive, and possibly the most deficient, soil element—nitrogen. The roots of this cover crop also liberate other elements of fertility. The soil bacteria take the free nitrogen from the air and combine it with the soil salts, when it is in form to be utilized by the trees. This is emphatically the cheapest way to secure the valuable and greatly needed nitrogen. We must have abundant water for both the cover crop and the trees. This cover crop should be plowed under not later than February, that it may be decomposed or converted into humus in the early spring as the probable moisture at this season promotes decomposition. To plow this under at so early a date and yet permit the plant to reach its full development requires that the seed of the cover crop be planted early—not later than September. In case of light rainfall in the autumn irrigation must be practiced, not only as the seed is drilled in, but also when needed afterwards. In this case broad, shallow furrows must be left so that irrigation can be accomplished whenever it is desired to water the plants. Some of our best citrus growers advocate and practice the planting of cover crops in summer, using at this season cowpeas. This may be wise in case one has abundant water, especially in a young orchard, but in this case we must be very careful that our trees are not robbed of the required amount of water. I can but believe that this is a questionable practice. The questionable practice of growing alfalfa in citrus groves is an increasing one. This makes a heavy demand on the water supply. Dr. E. W. Hilgard used to say that alfalfa hay was easily worth eight dollars per ton to plow under as a fertilizer. Dr. C. G. Hopkins maintains that growing alfalfa, just to use to fertilize our orchards, is well worth consideration. (See the Monthly Bulletin, Vol. I, No. 9, page 641.)

Many utilize the space between the young trees by growing an extra summer crop of some useful vegetable. In such case nothing is better than beans, as these tend to make the soil loose and friable, and as these are legumes, they really enrich the soil by adding nitrogen, as we have already explained. Beans are also one of our most profitable field crops. Many, however, grow no secondary crop, preferring to give the trees, old or young, all the fertility that the soil possesses.

As the grove reaches on toward maturity the presence of abundant humus is more and more important, and so the cover crop must not be

neglected. Stable fertilizer should be used in generous proportions, with scarcely any limit in the case of clay soils. Straw, especially bean straw, is particularly valuable. Commercial fertilizers are also to be recommended. While the abundance of potash in our California soils would seem to sustain Dr. Hilgard's contention that we need not add this element to our soils, yet some of our most intelligent growers feel sure that they have secured much advantage in the use of this soil element. Dr. Hopkins maintains that limestone, ground coarsly, is often more needed than potash. (See The Monthly Bulletin, State Horticultural Commission, Vol. I, No. 9, page 424.) Dr. Hilgard urges also that the phosphates are likely to be the first fertilizers that will be called for by our California citrus orchard soils. It is never safe to neglect advice of one so thoroughly informed, and one who has had such valuable observation and experience as has had Dr. Hilgard. Dr. Hopkins states, as already mentioned, that many soils are more likely to be deficient in lime than in potash. The reason for this is, the greater solubility of the lime permits it to be washed from the soil. (See The Monthly Bulletin, State Commission of Horticulture, Vol. I, No. 9.) It makes no difference whether we use rock or bone phosphates, as phosphates are phosphates, whatever their origin. In case either of bone or rock, the treated or superphosphates are more readily and quickly available, but if the untreated are ground very fine and added to a soil rich in organic matter, and if the bone is steamed, they will answer well and in time will all be utilized, so that really nothing is lost. The potash and phosphates should always be placed deep in the soil. The presence of humus insures organic acid, which renders the phosphates available. The phosphate slag affords also a cheap and valuable fertilizer, when procurable.

The most costly fertilizing element—nitrogen, so necessary because it enters into every living cell, plant or animal—will be much in evidence in case we have followed the foregoing advice regarding the use of cover crops and stable or barnyard manure. Yet we may find it advisable to secure it in more ample quantities. Many use Chili saltpetre or nitrate of soda. This in the cool days of early spring brings a quick response from all vegetation. It is, indeed, very quickly available as it is very readily soluble. For this reason it is quite likely to be washed out of the soil and lost. The late Dr. Frank H. King, one of our greatest soil chemists and long time professor in the University of Wisconsin, urged great caution in the use of this sodium nitrate. The nitric acid is very likely to let go of the soda and unite with some other base, and the carbonic acid of the soil will at the same time couple with the soda, and thus we will have formed sodium carbonate, the black alkali, which, as we know, is a very serious enemy of nearly all plants.

In soils that are poorly drained we often have too much of this black alkali without adding any more. Its presence may not be apparent at once, but we are storing up trouble for our children, or the future owners of the land, if we use this Chili saltpetre, especially on poorly drained soils. If, however, sodium nitrate is used in connection with gypsum less harm will occur. The organic nitrogen secured in dried blood and tankage is without objection, and though slower to act, is very sure to be available sooner or later, and can be used with little or no loss. It is well to remember that the Germans, among whom are many expert scientists, advise and use much commercial fertilizers, much more than we do in America. It is also significant that their crop production is often much heavier and of finer quality. We must remember that our citrus trees are tremendous producers, and so must be very generously fed. Indeed, our most successful growers in California are generally those who use commercial fertilizers in greatest abundance. It is not presumptious, I think, to predict that in the near future all citrus growers will grow luxuriant cover crops, will use abundant stable fertilizer, and will supplement these by a liberal use of commercial fertilizer. I am glad to append here the practice of some of our best orchardists.

The late Judge A. F. Call, of Corona, California, was a successful citrus grower and spoke from experience. He thought lemons need more nitrogen than do oranges; preferred organic or a slow-acting nitrogen; supplied the orange with nitrogen in the spring and the lemon in both spring and fall; he used no potash; he believed phosphoric acid valuable, would apply it at any time, but wished it drilled deeply in the soil; he was a firm believer in cover crops.

Mr. Frank L. Palmer, of North Pomona, would use for phosphoric acid high grade tankage early in the season; or, if bone meal is preferred, plows it under in the early winter. He often adds superphosphate in midsummer, drilling it in after irrigation. He believes in sulphate of potash, applied with drill in the fall. He decides at the beginning of the year how much of each fertilizer he will use throughout the season, and then uses the separates to supply the amount desired.

Mr. C. C. Chapman, of Fullerton, uses from fifteen to twenty pounds of complete fertilizer, containing nine per cent nitrogen to each large tree. He supplements this with three to four pounds nitrate of soda in the early spring. He applies five to seven pounds of potash and ten to fifteen pounds, running eighteen to twenty per cent of superphosphate, or eighteen to twenty pounds, running twenty to thirty per cent of ground bone. He drills in deeply, all but the nitrate of soda.

The question of using home-mixed or separate, fertilizers, or a complete fertilizer, is not easy to answer. That the latter is most expensive there is no question. If one is willing to study the question thoroughly

and proceed with wisdom and energy, there is little doubt but that to use the elements separately, or to mix them at home, will save much money and will give good results.

## IRRIGATION.

It has already been suggested that trees should never be allowed to feel the need of water. Lack of proper irrigation is the cause of many of the failures in citrus culture. Irrigation should be deep down. If the grade in the orchard is slight, the run need not be so long. If great, it should be longer and the stream smaller. Cross furrows made with a subsoiler twelve or fourteen inches deep will often give excellent results. Zigzagging the furrows among the trees, so as to get water on all sides of each tree, gives the water better chance to get down to the roots, and is often practiced with no little satisfaction. The great desideratum is to give plenty of moisture to all of the roots all of the time. It will pay admirably to dig a ditch from just under the trees to the middle point between four trees at different parts of the orchard, and at not too long intervals of time, to note just the condition of the soil as to moisture and the way the roots are developing. Such practice will often bring great surprises to the orchardist, who vainly imagines that his trees are being liberally supplied with all needed moisture. The King soil tester is less valuable only as it fails to show root distribution. It costs about seven dollars, and is worth many times that amount. It enables one to investigate the subsoil six feet down from the surface very quickly, easily and cheaply.

In case of a side hill, we may follow the practice so common in Calabria, Italy, and in parts of Switzerland, of terracing the hill slopes, though it is usually more satisfactory to contour the slope as we plant our trees, and thus we may irrigate as easily as we can on a more level field. The great Arlington orchard of Riverside County, and the Limoneira orchard of Ventura County are examples of where this last method is practiced with entire satisfaction. As previously stated, the grade of the orchard must be made perfect before trees are planted.

In the citrus groves, no matter what age, filling the furrows and cultivating the ground should be practiced just as soon after a rain or irrigation as it is possible to get on to the land without injuring it. Indeed, the ground should never be permitted to bake. The gauge to proper tillage with a clay soil is the entire absence of lumps or clods. In plowing clay soil it is the wisest plan never to leave the field until all the day's plowing is thoroughly harrowed, as the possible lumps are easily pulverized while they are yet moist.

It remains to be said that clay soils are more retentive of moisture than are sandy soils, and will need less and less frequent irrigations;

that sandy soils will be more retentive of moisture if well supplied with humus; and all should remember that no thorough orchardist will wait until his trees show by wilt of foliage that they are thirsty before he turns on the water.

## PRUNING.

After the shaping up of the yearling orange tree little more pruning is called for, other than to cut out all the dead limbs or to cut back or off the too ambitious suckers or water sprouts; though if the trees are headed low, as they should be, it will be wise to trim up from the ground only enough to permit cultivation of all the surface soil close up to the trees. This low heading protects the trees from the sun. Some of our most excellent orchardists prune, even the orange, more thoroughly, cutting out the weakest of all competing branches and letting in the sun, believing that they thus secure larger foliage and more fruit wood. With the lemon, more pruning is usually done. It is found that more and better fruit is secured if the trees are cut back and the centers somewhat thinned. It is now the common practice of our best lemon growers to thin out and cut back the branches every year. These prunings in small orchards may be cut up by the use of a hand pruner, though many orchardists use a cutting box, which runs by power and is drawn between the rows of trees, to cut these prunings into rather short lengths, which are then plowed under. I believe this is a very wise practice. Those with small holdings may combine and secure a power cutter to be used in common. There is one custom among almost all citrus fruit men that I can but believe is wholly wrong. I refer to the fact that the branches are permitted to hug the ground. This precludes cultivation close up to the trees, and if there is a growth of grass or weeds under the trees in early spring and on up to summer, this is likely to be untouched, and there is a heavy loss of water by transpiration from this undergrowth. If the soil is not broken up, it is dead soil, and there is great consequent loss. I am firmly of the opinion that the whole soil close up to the tree should be mellowed deeply at each cultivation of the orchard, even though general practice is to the contrary, *so that there may be a splendid, dry, fine earth mulch, of at least four inches, always covering the entire surface of the ground.* Some of our ablest orchardists, notably Mr. C. C. Chapman of the "Old Mission" brand, practice this low pruning, and are

not content unless all of the soil is mellowed everywhere, even up to the very trunk of the tree. It is only in a mellowed, aerated soil that the bacterial action, so necessary to root activity, can take place; so all uncultivated area is waste land. He who leaves the earth under the tree hard and uncultivated is satisfied with the "half loaf" when a whole one is entirely within his reach.

## SCHEDULE OF CULTIVATION.

The first cultivation of the calendar year will generally be when the cover crop is plowed under in February. If a too wet soil forbids work in February, then as soon thereafter as the soil is in condition to be worked. This early plowing promotes rapid decay, as the moist soil induces bacterial action, and is best done by the use of a disc plow, and disc harrow following right after, as any other will tear up some of the vetch, etc., which should be kept wholly under the surface soil. In case cover crops are not grown, many prefer to plow in January. This is a good time to plow under bone meal, tankage or other organic fertilizers. The cultivation after this, until September, should be just sufficient to preserve the four to six-inch dry earth mulch. Cultivating at varying depths prevents the formation of irrigating hardpan, which must never be permitted to form. Early deep plowing also helps to prevent the formation of plow sole. Of course cultivation will follow irrigation as soon as the soil can be worked without injury. In September the seed for the cover crop will be drilled in after the phosphates have been placed deep down in the soil. These latter may be placed in the furrows or drilled in in case one does not plow. If necessary, the cover crop should be irrigated in the fall months, and if desired, the crop can be grown in drills far enough apart to be cultivated. Some excellent citrus growers are growing alfalfa in their orchards as an experiment, in which case no cultivation is required, and bacterial nitrogen is being manufactured in the soil every week of the year. In this case much water must be at one's command and most liberally used. This is better grown in alternate rows of the orchard for three years, then plowed under and the other rows utilized for alfalfa as before for the same period. This practice has not been general at all, but some, notably Mr. Hampton, of Corona, who have tried it have expressed themselves well pleased. Dr. Hopkins suggests that alfalfa be grown in a separate field, hauled to the orchard, and worked into the soil. He says it is as well to convert this into concentrated fruit products, like oranges and lemons, as into beef, pork and mutton.

# TOOLS AND IMPLEMENTS FOR CITRUS ORCHARDS.

By one of the most experienced and successful citrus growers of California.

**Wagon.** Perhaps first of all is needed a substantial wagon with strong bolster springs for hauling fruit and other miscellaneous purposes about the place. Most orchardists prefer low wheels for convenience of handling.

**Plows.** A strong 10-inch or 12-inch share plow is almost indispensable, as is also a smaller 6-inch or 8-inch plow. The old-fashioned mold-board plow with roller coulter and chain is considered a superior tool for plowing under the cover crop. When properly handled, and not always run at the same depth, it most effectively stirs the soil and buries the green manure deep below the surface.

The disk plow throwing one or two furrows is in very common use for orchard plowing, and for handling a heavy growth of vegetation it is easily operated without the annoyance of coulter and chain. It is also well adapted to stony ground, though its work, even there, is not the equal of mold-board plowing. Either the mold-board or disk plow will require two, four or six horses, according to depth. Large horses, or better, mules, are a requisite in citrus culture.

Whether using the mold-board or disk plow it is usually necessary to break out the first furrow or two next the trees—or the last furrows, as the case may be—with the smaller walking plow drawn by a single animal, or by two hitched tandem.

**Harrows.** The adjustable tooth-harrow is in frequent demand for following the plows on cloddy soil and for dragging over the irrigated furrows in advance of the cultivator.

The disk harrow is indispensable for use on ground covered with litter of any sort. The orchard extension-disk harrow is so designed that it may be operated well back under the trees when desirable, and at other times altered so as to cut no more than five feet wide. When extended one group of disks works under the tree while the other group works out in the center of the space, leaving six feet between them to be worked with another disk or to be disked later when the extension rods have been removed and the two groups of disks set close together.

**Cultivator.** The cultivator must be strong enough to cultivate freely to a depth of ten inches when desired, and it must be so constructed that it may be operated at varying depths and forced to those depths by its full weight and the proper type of shovels or chisel teeth.

Hinged extensions on the ends of the cultivator beam are often used for cultivation under low-hanging and wide-spreading trees.

**Marker or Furrower.** The marker, for making the irrigation furrows, is not unlike the cultivator in strength and design, except that it carries on its beam only two, or three, sometimes four or five, stout broad shovels, depending on the number of furrows desired. It is a common practice among smaller growers to alter the cultivator each time marking out is necessary by the mere substitution of shovels for the teeth, reversing the operation again before cultivation is necessary. Thus one tool serves a double purpose.

The marker may be extended in the same way as the cultivator.

**Subsoiler.** (Fig. 15). This is a most important tool in the citrus orchard, and yet it is probably the tool that has been used least of all. Cross subsoiling to a depth of from sixteen to eighteen inches at right angles to the irrigation furrows and midway between the trees greatly facilitates deep irrigation and improves the aeration of all of the soil.

FIG. 15.—Subsoiler at work in an orchard. (After Lelong.)

An occasional subsoiling, say every third year, of the entire cultivated area at intervals of two feet and in two directions to a depth four inches below the deepest plowed and cultivated depth will break up plow sole or irrigation hardpan and supply the much needed air that is too often shut out from the roots.

**Drills.** The seeding of cover-crops is usually done with the drill. The "disk" drill instead of the "hoe" drill has many advantages where trashy ground may be encountered.

Commercial fertilizer is usually drilled into the soil and to as great a depth as possible. A tendency to believe in applying a part of the

fertilizer underneath the spread of the branches or as close to them as possible has called for a low, squat drill with seeding box extending out at either end beyond the wheels. This is well exemplified in some of the later models of orchard drills now on the market.

Efforts to put on the market a satisfactory combined seeder and fertilizer drill that will handle all kinds of both materials in the proper quantities per acre have not as yet been altogether a success. Such a drill is greatly needed for the smaller orchardist. He who has but a few acres may more profitably hire his seeding done, or rent a drill, or perhaps own a small interest with others in a community drill, because the tool is used so very seldom during the year. The same applies to the fertilizing.

**Spraying Outfit.** In most localities the spraying of citrus trees at one or another season of the year is a commercial necessity. Small orchardists usually find it cheaper to buy and mix their own materials and hire the owner of a machine to come and do the spraying. In the larger grove the power spray outfit, with gas engine, force pump and 200-gallon to 250-gallon tank with agitator, is now a part of the regular equipment. Very satisfactory work is being done with the barrel spray pump in some small orchards. This requires one man to operate the hand pump while another handles the nozzle.

**Miscellaneous Tools.** Other tools might be mentioned, such as the one-horse cultivator and one-horse marker often used in young orchards, the "cyclone" and "straight knife" for cutting weeds, the spring-tooth harrow, the reversible disk and share plows for hillside and special needs, the brush cutter for chopping up the prunings to be thrown into the orchard for mulch, the manure spreader, tank wagon, fumigation cart, scrapers and drag-floats for leveling and grading the land, long handled and hand pruning shears, curved saw, grafting wax or, if preferred, thin putty, clippers with curved points, King's soil tester, ladders and other picking equipment, pruning tools, and the many smaller hand tools. But these are either such common ordinary tools that each man is in a position to enumerate his own needs and select the best obtainable in his community, or they are tools that may be dispensed with altogether except under such conditions as confront the larger orchardist or the orchardist whose needs are exceptional.

**Single-trees and Double-trees.** At all times and in all places in the orchard the shortest possible double-trees and single-trees should be used, as at best they are a great menace to smooth and low-hanging branches. Leather protections, or guards, over the clips are wise precautions.

# PICKING.

There are three things which must be carefully observed in picking citrus fruit. First in importance is careful handling. This applies to all kinds of citrus fruit. They must not suffer the least bruise, as any wound forms a seed bed for the ever present blue mold spores, which are terribly fatal to successful shipping; no clipper-cut wound; no thorn-puncture, no bruise from rough handling. The uninjured skin of an orange or lemon is resistant to the common process of decay. Mr. C. C. Chapman called attention to this in his admirable lecture at the Long Beach Seaside Institute about 1904. But until Dr. G. Harold Powell demonstrated the importance of this care thousands of dollars were lost, where there is now hardly any loss.

Again, care as to the size is also important. Picking with a ring makes this sure and easy. The orange box, which is 11½ by 11½ by 24 inches, will hold as follows:

| Number in box | Diameter in inches | Size of wrapping paper |
|---|---|---|
| 80 | 3¾ inches | 12 by 12 |
| 96 | 3½ inches | 12 by 12 |
| 100 | 3½— inches | 12 by 12 |
| 112 | 3¼ inches | 11 by 11 |
| 126 | 3⅛ inches | 11 by 11 |
| 150 | 3 inches | 11 by 11 |
| 176 | 2⅞ inches | 10 by 10 |
| 200 | 2¾ inches | 10 by 10 |
| 216 | 2⅝ inches | 9 by 9 |
| 250 | 2½ inches | 9 by 9 |
| 299 | 2⅜ inches | 8 by 8 |
| 324 | 2⅛ inches | 8 by 8 |

The lemon box, which is 10⅜ by 13½ by 25, will hold as follows:

| Number in box | Diameter in inches | Size of wrapping paper |
|---|---|---|
| 210 | 2¾ inches | 10 by 10 |
| 240 | 2⅝ inches | 9 by 9 |
| 270 | 2½ inches | 9 by 9 |
| 300 | 2⅜ inches | 8 by 8 |
| 360 | 2¼ inches | 8 by 8 |
| 420 | 2⅛ inches | 8 by 8 |
| 442 | 2+ inches | 7 by 7 |
| 490 | 2 inches | 7 by 7 |

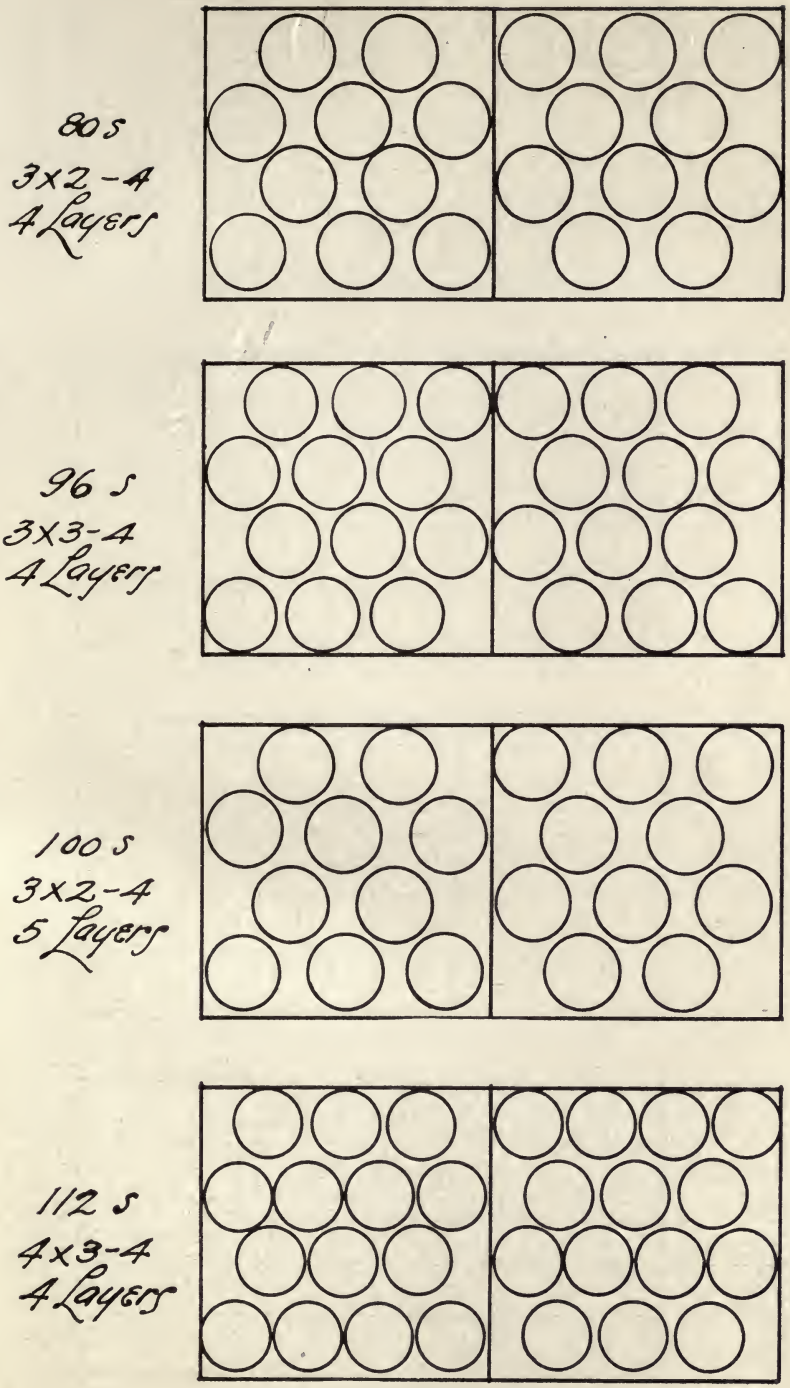


FIG. 16.—Orange packs.

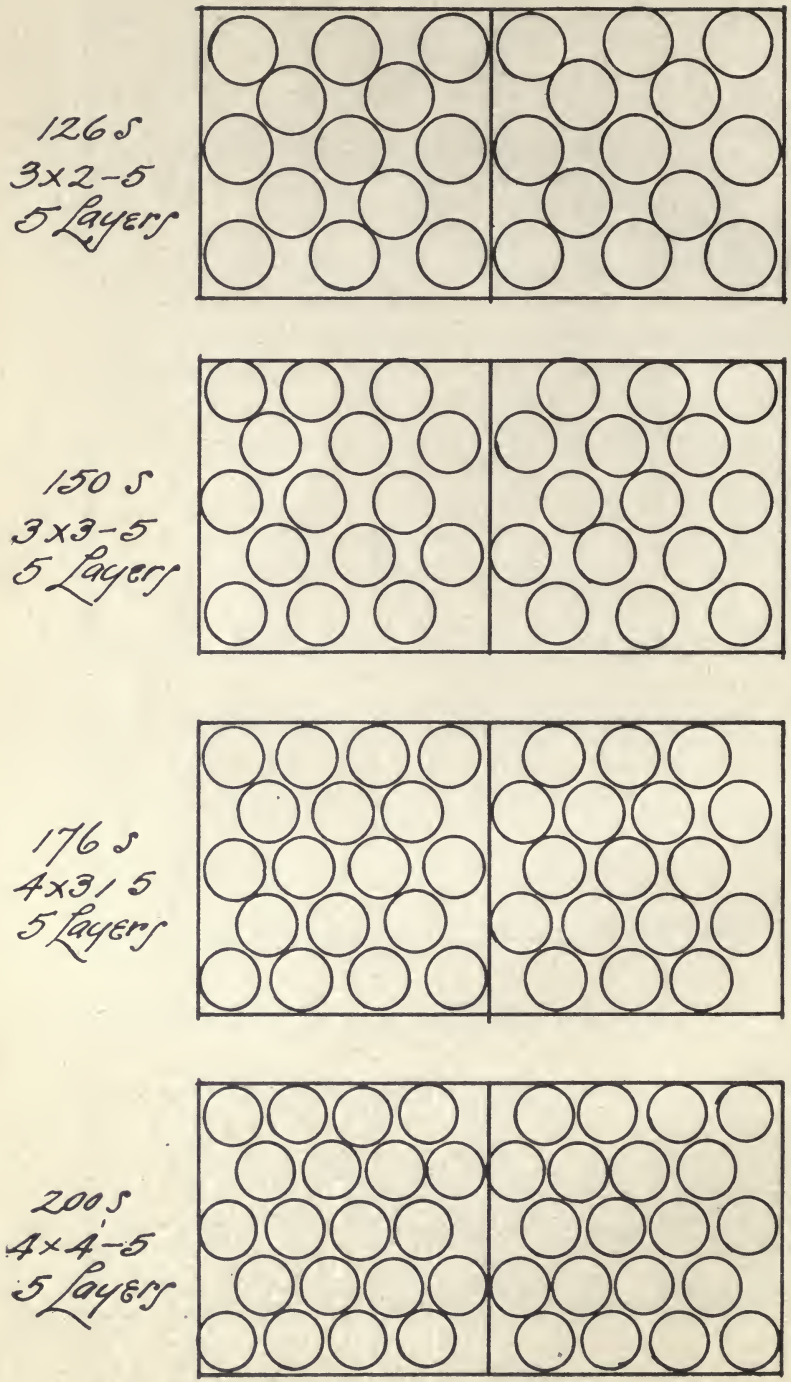


FIG. 17.—Orange packs.

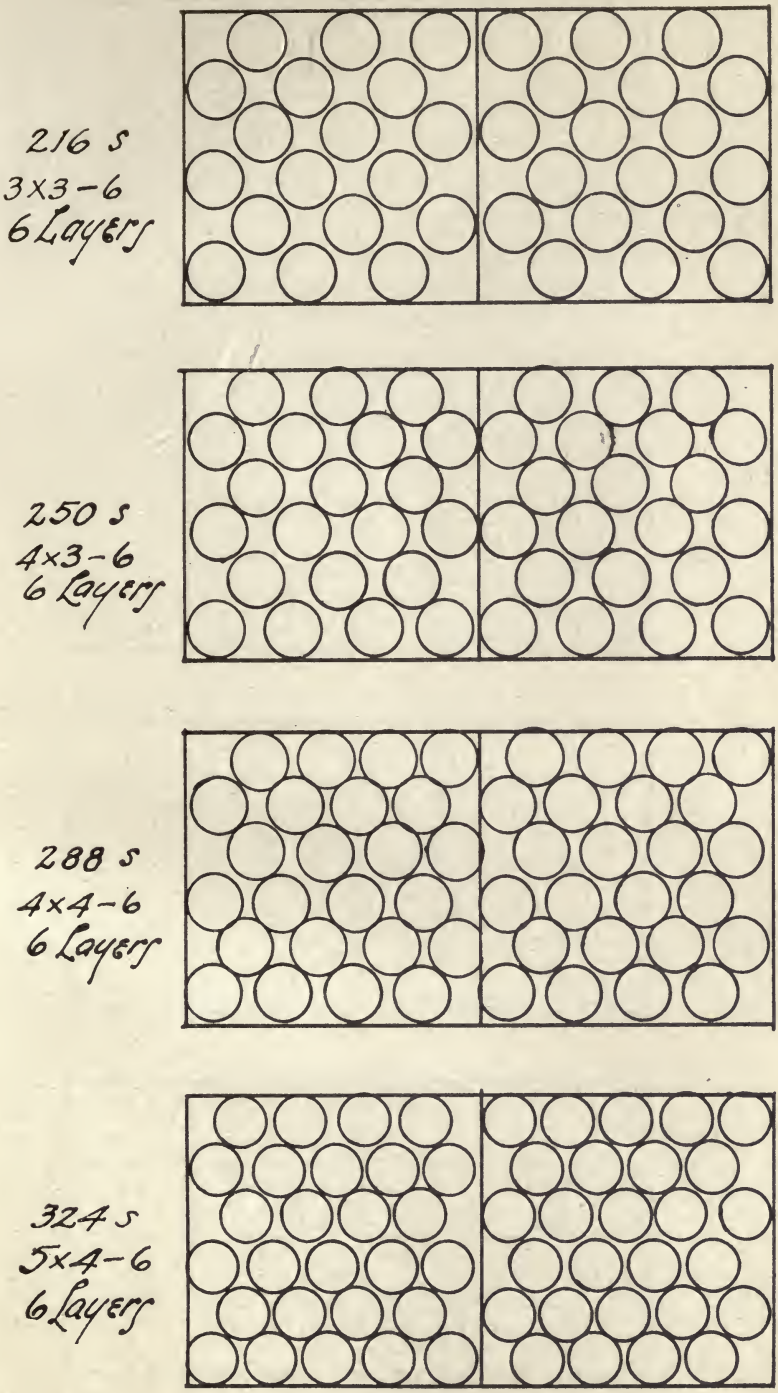


FIG. 18—Orange packs.

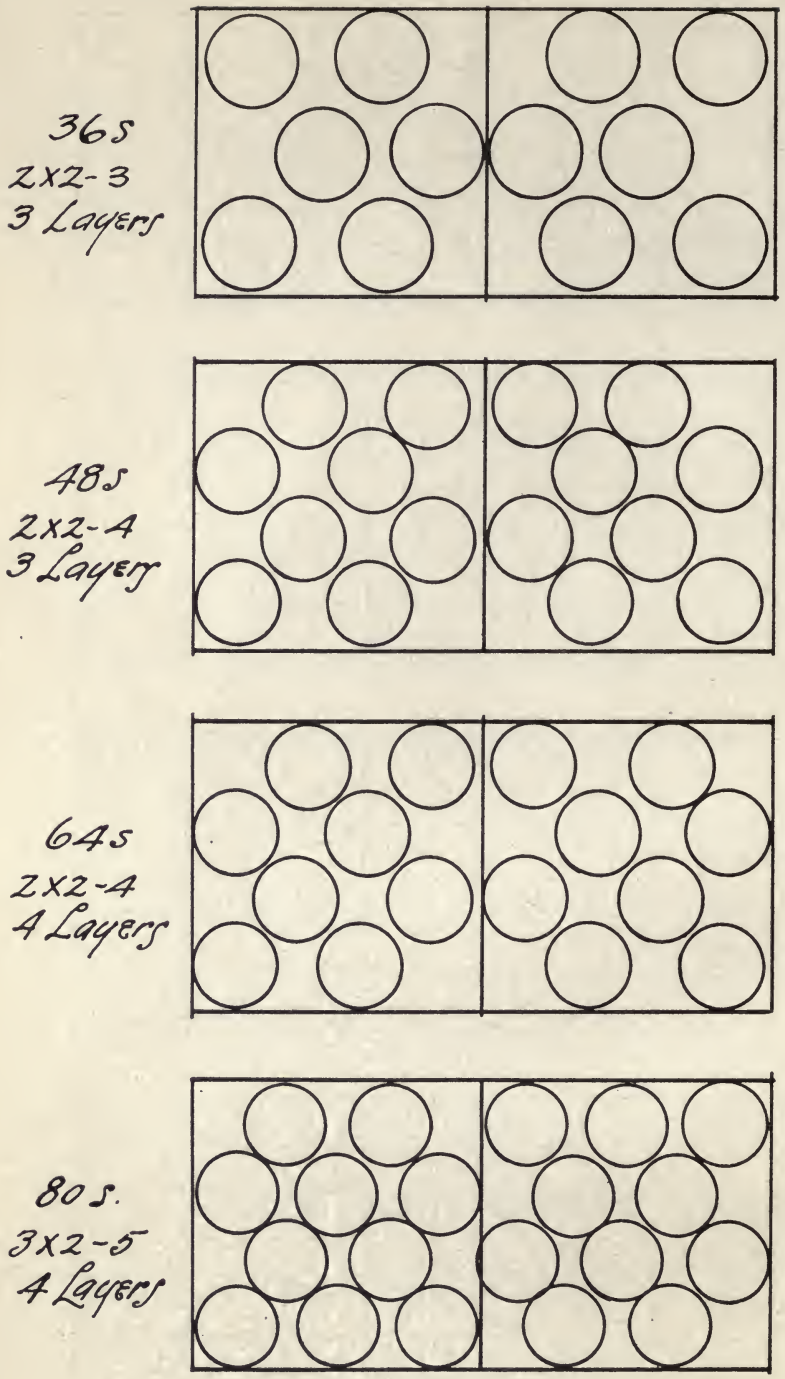


FIG. 19—Grapefruit packs.

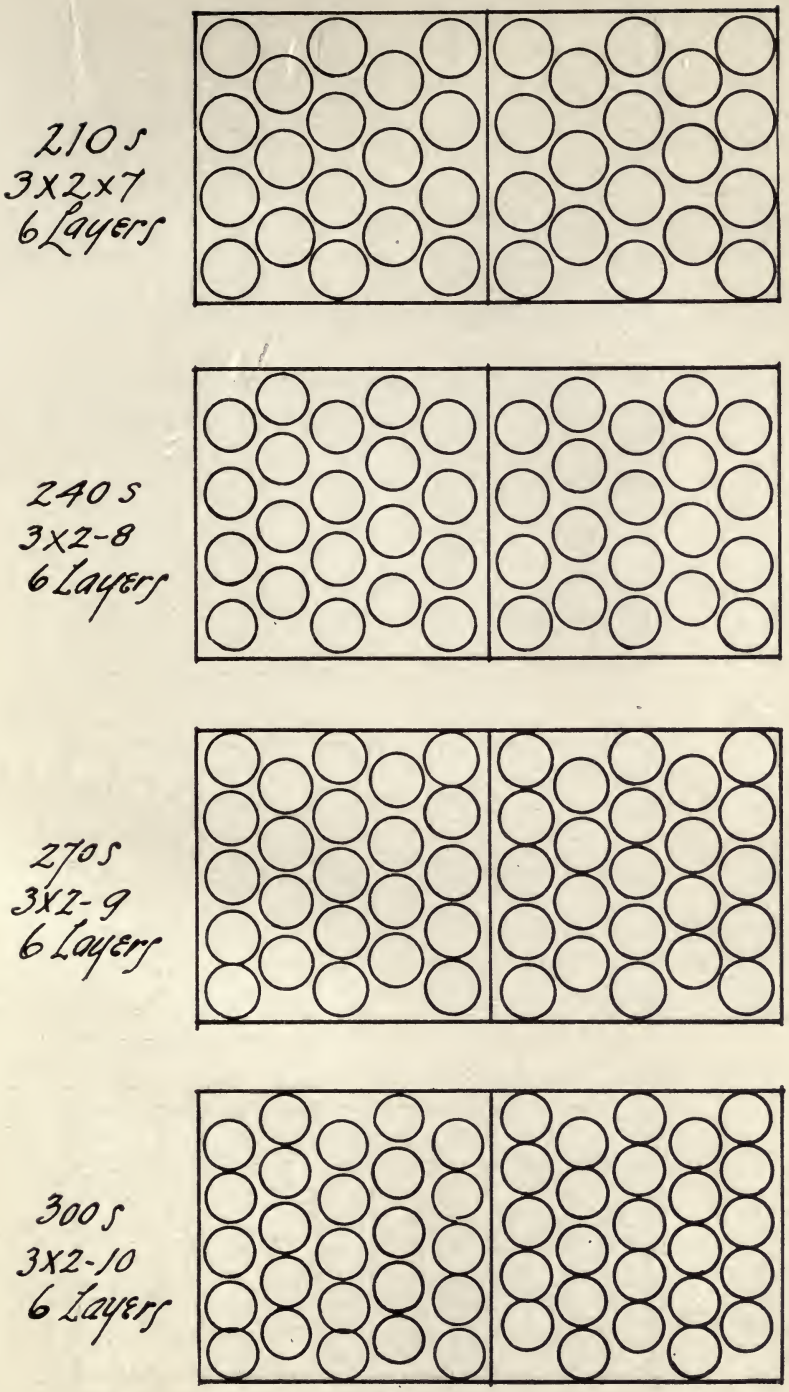


FIG. 20.—Lemon packs.

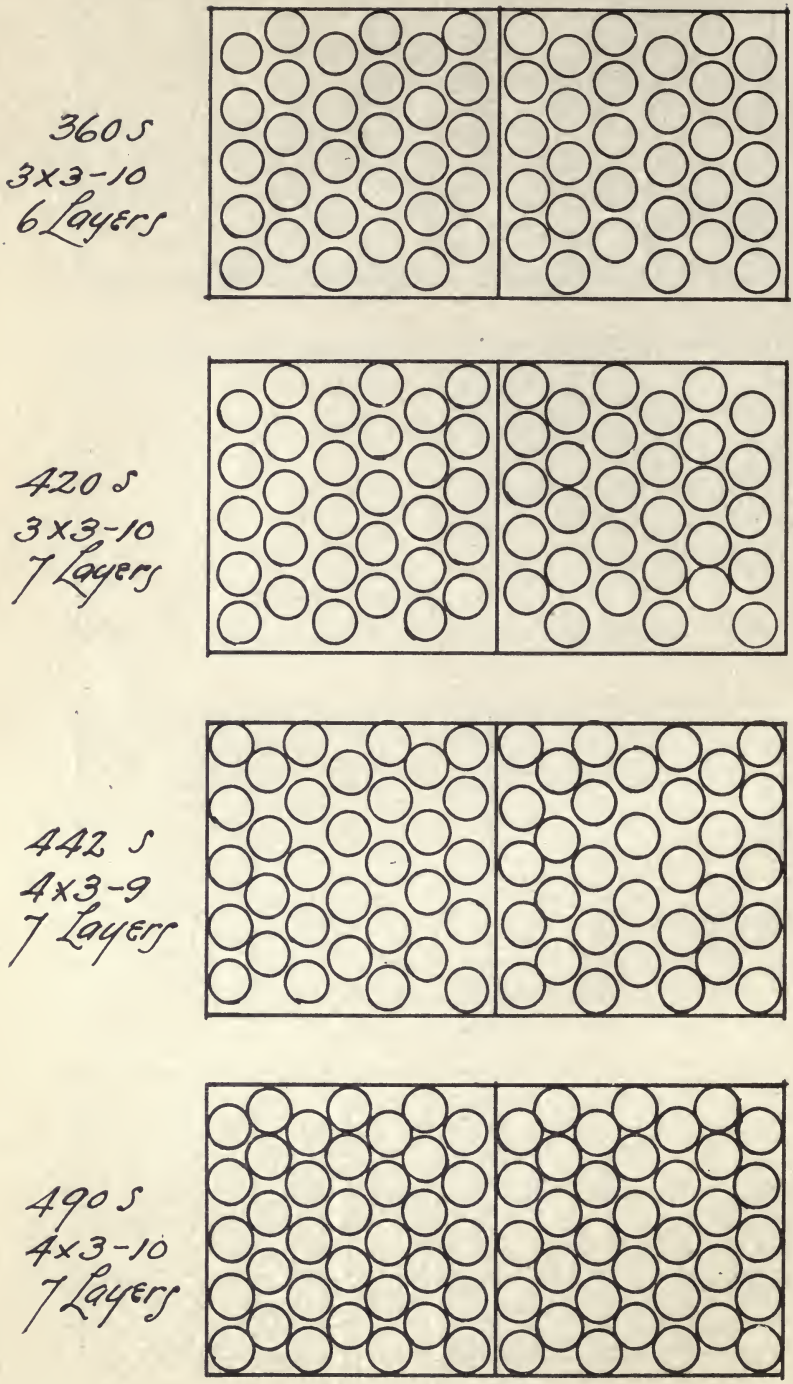


FIG. 21.—Lemon packs.

A box of oranges will hold from eighty to three hundred and sixty, according to size. The weight will vary with variety, but will average about sixty-six pounds of fruit; the total weight averaging about seventy-five pounds. In case of oranges and pomelos, they are not picked until ripe, or should not be, while lemons are better picked green, especially if a desirable size is attained. Lemons picked green and cured in the packing-house will ship better and are the only ones suitable for long shipment. All lemons, except those that ripen on the trees before reaching the desired size, are cured in the packing-house. Oranges and pomelos are usually kept only two or three days until the skin softens by evaporation, when they are more easily packed. Pomelos are sometimes held successfully for weeks before shipment. The lemons must color and this takes time. This curing improves the appearance, thickness and texture of the lemon peel, giving it a soft kid-glove finish. Lemons are sometimes kept in the packing-house for ten weeks before they are sufficiently cured. It is possible to hold them much longer than this if market conditions require it.

The fruit should always be picked by use of curved-pointed clippers and the picking sack, which can be carried and emptied without bruising the fruit, and should be drawn to the packing-house on cars or wagons with good springs. The rule to be observed, ever and always, "handle all citrus fruits as though they were eggs."

# THE PACKING-HOUSE.

The packing-house of to-day is a masterpiece of study and skill, and is the result of much thought and experience. The precooling, automatic handling, and easy, gentle working are a surprise to one a stranger to such perfection. A description of the model packing-house of to-day would take much time and space. The only way to become informed is to visit a model house. The lemon house of the Limoneira Company at Santa Paula, where the Teague tents permit easy and ready ventilation, and cheap, admirable curing, represents one type; while the other type with its refrigerator room is well shown in the model house at Pomona. Both types should be visited and thoroughly studied by those contemplating building a packing-house.

A lemon must be perfectly clean and bright, and so must be washed. The washer must do its work very gently. We must remember that none but the best is good enough. So much of intelligence is now devoted to citrus culture that he who would succeed must be mindful of every slightest detail. To-day picking gangs under an expert manager are working so carefully and well that decay is greatly reduced. Soon all citrus fruit will be picked by skilled pickers. The wrapping and packing is now a work of art, and this is well, as a neat pack will enhance the selling price beyond belief.

## GRADING.

Grading is a matter of great importance. The grading for quality is done by hand, the sizing is done by machinery. Lemons are usually sized by hand. The "fancy brand" must be bright, smooth and perfect. "Choice" must be bright, but the skin may be a little rough and thick. "Standards" are less perfect in appearance, but are merchantable. "Culls" take all unmerchantable fruit. These may be plowed under as a source of humus. Oranges before the sugar is developed or when frosted should never be shipped at all. Such fruit is very likely to be sold at a loss, and is very prejudicial to the interests of the industry as a whole. Mr. C. C. Chapman said at the Long Beach Seaside Institute in 1904 that his brand, "Old Mission," was worth as much as the fruit itself. It should be the aim and determination of our citrus growers to establish a brand that would be famed the country over.

# PLANT DISEASES.

Plant diseases may be considered under three heads: Physiological, or plant sickness, fungous and insect attack. There are several ailments that are wholly physiological. The plants or trees are sick. The most common of these is chlorosis.

**Chlorosis, Yellow Leaf, Variegated Leaf or Mottled Leaf.**

This peculiar color is doubtless simply symptomatic. As pallor in man, so chlorosis in plants, denotes disease—something is wrong. As in

FIG. 22.—Die-back on orange: A, showing gum pockets; B, cross-section of a Valencia, showing gum at core; C, twig showing multiple buds and dead tips. (After Essig.)

case of all physiological troubles the thing to do is to search for the cause of the ill, and then apply the suggested remedy. In clay soils with poor drainage the earth may be water logged, in which aeration is impossible, and we have a dead soil. This last condition follows from a hard, cemented soil, consequent upon imperfect cultivation. Artificial or natural hardpan will also produce the same condition. Again the plants may be thirsty and suffer from lack of moisture. The soil may be impoverished and the plant cry out for food. Probably the great cause is "malnutrition," including both food and air. The artificial hardpan referred to is a cemented soil, just below the plane of deepest

cultivation, usually consequent upon the cementing lime carbonate in the water used in irrigation. Cultivating at different depths will tend to break this up and relieve the trees. Dynamite will break up the deep or natural hardpan. The trio of remedies for physiological ills is right irrigation, cultivation and fertilization.

### Exanthema—Florida Die-Back.

(Fig. 22.)

This disease is not well understood. The ends of the branches die; frequently tufts of small twigs develop from supernumerary buds; the bark roughens and shows lines of brown excrescence; gum pockets form near the attachment of the leaves; the fruit is imperfect and often pale yellow and insipid, and gum forms in the fruit close about the core; dark green leaves appear, which, though they would seem to indicate health, are really the result of the disease. It is claimed that gravelly soils with coarse gravel for subsoils, or soils underlaid with hardpan promote this disease, as do large applications of stable fertilizer on such soils, especially if the trees have previously lacked plant food. As above advised, good care and removing the cause when possible is the only known cure.

### Gummosis—Gum Disease.

Mr. H. S. Fawcett has shown that gum disease is often fungoid. The gum is an incident. Fungoid attack of the bark is the real disease. It affects all kinds of citrus trees, but lemons suffer most. Gum exudes at various places, but in case of lemons, most at the crown near or at the place where the bud was inserted. Injuries, improper irrigation and earth compacted about the spot where the bud was inserted are enough to cause the disease. It is best to have the bud above the earth and avoid running water about the crown.

Mr. Fawcett has produced gum disease of the lemon by inoculations with the decaying bark; also from cultures. He finds two distinct forms, both produced by common molds of the packing-house. In one, the brown rot fungus (*Pythiacystis citrophthora*), the decay of the inner and outer bark is almost coincident, and the diseased bark remains hard, while in the other, gray fungus (*Botrytis vulgaris*), the outer bark decays before the inner, and all becomes soft. The cure for both is Bordeaux paste. (See Monthly Bulletin, Vol. 2, No. 8, page 601, August, 1913.)

### Psorosus—Scaly Bark.

(Fig. 23.)

This trouble, not found in the lemon, is described in its name. The cause may be improper aeration or irrigation. When serious it is often

fatal. When only small areas or branches are attacked, by cutting out and painting with wax a cure may be effected. This, like gummosis, is not contagious, though its nature and cause are not fully known. This and mal di gomma described below may prove to be fungoid.

FIG. 23.—California scaly bark or psorosis on orange. (After Fawcett.)

### Mal di Gomma—Foot Rot.

This is only met on water-logged, clay soils, and is often fatal if not speedily treated. There is decay of the roots from the origin down,

which is serious. Removing the earth from the main roots, cutting out the diseased portion and disinfecting will usually effect a cure. Mr. R. P. Cundiff, of Riverside, California, claims to have used large quantities of gypsum, 50 per cent pure, working it into the earth about the trees with apparently excellent results.

### Splitting.

Here again the name tells the story. Oranges alone are attacked—the oranges split. It is probably caused by spasms of growth caused by irregularities in culture, irrigation or seasons. Navels, especially, suffer. As we should expect, it is much more common some years than others. We can do something, I think, by regularity and punctuality in our care. Of course we can not control the seasons.

### Puffing.

This is described by the name. The rind of the orange bulges out in sections, is often very rough, and is easily injured in handling. I have seen it very pronounced in case of trees pushed to extremes, by excessive fertilization. The orange loses its flavor and is likely to become worthless. Soil and season seem to influence in this affection, and, as we should expect, it is more serious some years than others. Improper irrigation may be provocative of this disease.

### Peteca.

In this disease, which is usually seen only in the packing-house on lemons, there is a pitting of the surface of the fruit. It is injurious only in marring the appearance of the lemon. The cause is obscure.

### Brown Spot.

This is a serious affection, more frequent in the navel orange, which marks the rind of the finest fruit, and appears only after the fruit is picked for some days. Often there is no discoloration until the fruit is shipped. It is early picked fruit that shows the spot. The cause of this spotting is not certainly discovered. It would seem that some injury to the epidermis of the fruit may be the seat of the trouble. Brown spot is much less common near the coast. I first had samples from San Fernando, then San Dimas, then Redlands, where that first season it injured fifty per cent of the early picked fruit.

### Fungi, Molds, Etc.

Our citrus trees often suffer severely from the attacks of fungi. These very simple organisms are among the lowest of plants. They develop no chlorophyll, do not take oxygen, but depend upon other

organisms for their support. If the supporting organism is dead, we call them saprophytes, in which case they do no harm. If living, then they are parasites, and may work us great harm. They often produce myriads of spores, very small seed-like bodies by which they reproduce. Many put forth minute, thread-like growths, called hyphæ, or the tangle, mycelium. These threads which form the common mold, push into the living tissue and sap from it its substance, or, to state it otherwise, feed upon it. The larger and more highly developed are familiar to us in the toadstools and mushrooms, others in the rusts, molds and mildews.

**Blue Mold (Penicillium italicum) and Green Mold (P. digitatum).** We are all familiar with these molds. The myriad spores give the color, blue or green. They are the common cause of rot in all citrus fruits, and are not uncommon in many other fruits. They attack almost exclusively injured fruit. This formerly was the cause of millions of dollars loss to citrus growers. The masterly researches of Mr. G. Harold Powell, expert of the United States Department of Agriculture, demonstrated the cause and remedy for this common rot, so that now the loss from this cause is much lessened. Clipping and handling the fruit so carefully as to produce no injury is a great preventive, and precooling or cooling it off in the cars by icing so that no spores can germinate, has decreased the decay very greatly. The motto of every citrus grower should be, "Handle all fruit as though it were eggs," and never bruise or wound in the least degree. Yet it remains to be said that some fruit, fruit from certain localities and fruit from orchards heavily manured, fails to stand up. There doubtless is susceptible fruit. It may be physiologically weak. The attack is also increased apparently by a continued moist atmosphere.

**Brown Rot (Pythiacystis citrophthora).**

This is a very serious enemy of citrus fruits. The brownish color is very characteristic. It is observed on the fruit, the leaves and lower branches of the tree, in the packing-house and in the packed boxes. It spreads rapidly from fruit to fruit, wherever they touch in boxes or elsewhere. There is a characteristic odor of decomposing oil. It is most common on lemons. The fungus grows and fruits in the soil and in washing the fruit in the packing-house the spores that have blown on the lemons in the grove collect in myriads in the water and play havoc with the fruit, by being carried to every lemon. Professor Ralph E. Smith and H. J. Ramsey, of the University of California (Whittier Experiment Station), in suggesting bluestone (copper sulphate) as a cure, and in working out methods of sanitary treatment in the packing-house, conferred a rare service to the industry and to the State. Bluestone is placed in the washing water in the packing-house. Straw

placed under the trees, and to a lesser degree a cover crop, helps to keep the spores from reaching the fruit. The usual strength of the bluestone water for brown rot is one and one half pounds to one thousand gallons.

This fungus, as we have seen, causes one kind of gum disease of lemon, see page 44.

### Cottony Mold or White Rot (Sclerotinia libertiana).

This is much like the brown rot, except that it coats the fruit with white. It attacks and often kills the twigs a foot or two from the end. In this mold develop black bodies (*sclerotia*), another stage in the growth of the fungus. This fungus also develops in the soil, and is more likely to attack lemons that are bruised. It is thought that cover crops, especially vetch, which is also a host plant, favors this fungus. Bluestone will aid in its control, but it must be stronger than for brown rot. Professor Smith suggests that it may not be safe to use it strong enough to be effective on account of injury to the fruit, in which case the remedy must be to destroy it in the field. This fungus has been found recently attacking the orange roots of full grown lemon trees, entirely killing the trees in many instances, at the same time causing more or less gummosis.

### Gray Mold (Botrytis vulgaris).

This is the dark colored decay of lemons in which a gray fungus develops. The fungus in the packing-house is not usually very serious, but as we have seen, it is a cause of gum disease. (See Monthly Bulletin, Vol. 2, No. 8, page 601, August, 1913.)

### Wither-tip (Colletotrichum gloeosporioides).

This fungus kills the twigs at their ends, spots the fruit and leaves, and fells the latter to the ground. Mr. C. C. Teague says that this pest has cost the Limoneira lemon grove more than all injurious insects combined. I saw the plague in Mr. N. W. Blanchard's orange orchard so bad that the foliage looked as if it had been blighted by fire. This disease is becoming more and more common in many orchards, and many are now fighting it with no little success. It seems to be erratic, depending on seasons. Bordeaux mixture and lime-sulphur spray are the specifics to use in its control. Care must be taken in the use of the Bordeaux or injury may result. This is the more true if fumigation follows soon after the spraying.

### Damping Off (Rhizoctonia and Fusarium).

Two fungi seem to be responsible for damping off. The first named fungus attacks the young seedlings at or just above the ground, causing

a decay of the crown or stem, while the second may produce dead spots at any point. Improper soil (it should be sand, at least on top), over-irrigation and insufficient drainage are favorable to this disease.

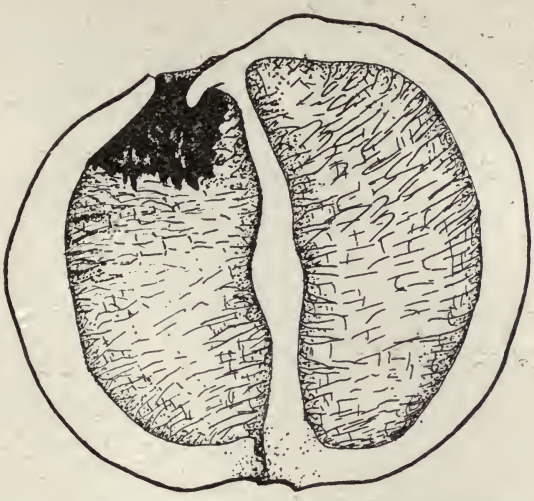

FIG. 24.—Navel or black rot, *Alternaria citri*, infecting the navel end. (After Amundsen.)

### Navel Rot (Alternaria citri).

(Fig. 24.)

This rot attacks only the navel orange. It is not a true parasite, and attacks the navel end only when it is injured in growth. It is thought that moisture in the navel cavity may favor the disease, as autumn rains seem to increase the affection. The navel is the finest winter variety for all around use, and its seedlessness adds to its excellence. This rot is one of its few drawbacks, but it is only occasionally that it becomes of serious importance.

### Root Rot (Oak-root Fungus, Armillaria mellea).

(Fig. 25.)

Where orange trees and many others replace oak trees in the foothills and valleys a toadstool fungus, which previously infested the roots of the oak, may attack and greatly injure the trees. It is common in California, and often serious. Mr. Earl Morris, county horticultural commissioner of Santa Clara County, regards it as the most serious pest in the orchards of his county at the present time. It spreads to other trees from the center of infection. Professor Smith suggests that in case this disease is troublesome other and more resistant trees, like walnuts or cherries, be grown in their stead. I have seen one case of

FIG. 25.—Pomelo attacked by the root-rot fungus. Notice the toadstools at the base of the tree. (After Horne.)

a serious attack on the walnut. Professor Horne finds pears and figs especially resistant to this disease.

All interested in citrus culture should possess Bulletin 218, Experiment Station, University of California, by Professor Ralph E. Smith and Elizabeth H. Smith. For one who wishes to study more deeply into this intricate subject of fungi, etc., Duggar's Fungous Diseases of Plants will prove admirable.

# INJURIOUS CITRUS INSECTS.

Insects are not so minute and obscure as are fungi, and their pestiferous work is much better understood. However, their ravages are often alarming. It is stated that by very conservative estimate the amount expended annually in California in insect control reaches the startling

FIG. 26.—Adult females and egg masses of the citrus mealy bug (*Pseudococcus citri*) on orange. (Essig, P. C. Jr. Ent.)

sum of one million dollars. The damage wrought by their attack doubtless far exceeds the million dollar mark. The United States government estimates the damage by the pear thrips alone in California for the last seven years at seven million dollars.

FIG. 27.—Cottony cushion scale (*Icerya purchasi* Mask.) on orange twig. (Cal. Hort. Com.)

FIG. 28.—Soft brown scale (*Coccus hesperidum* Linn.) on orange twig. (Essig, P. C. Jr. Ent.)

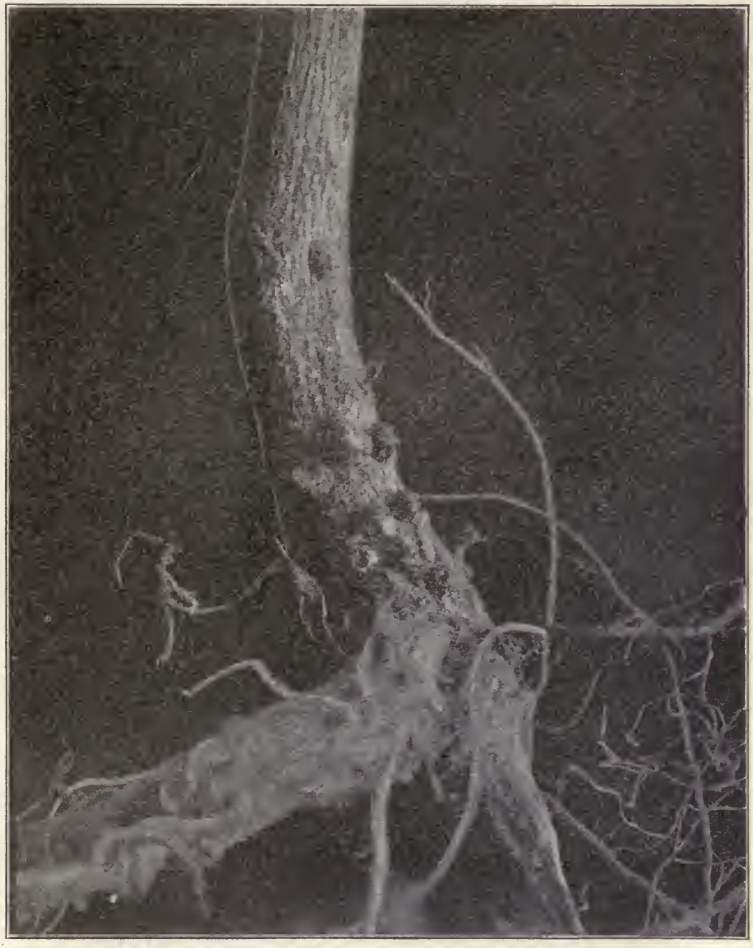

FIG. 29.—Full grown specimens of black scale, *Saissetia oleæ* (Bern.), at base of nightshade plant. Many of these were under the surface of the soil. (Essig, P. C. Jr. Ent.)

FIG. 30.—*Aspidiotus hederæ* (Vall.) on lemon and in such cases known as the lemon peel scale. (Essig, P. C. Jr. Ent.)

FIG. 31.—Red scale, *Chrysomphalus aurantii* (Mask.), on orange. (Essig, P. C. Jr. Ent.)

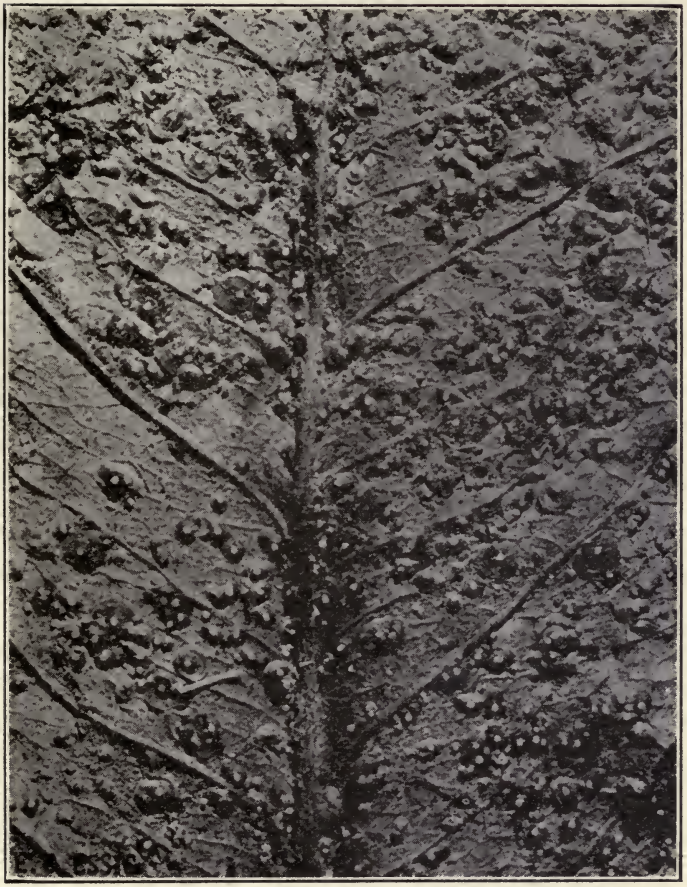

FIG. 32.—Yellow or citrus scale, *Chrysomphalus citrinus* (Coq.), on orange leaf. (After Essig.)

## CALENDAR OF PESTS OF CITRUS TREES.

| Pest | Work | Remedy | Time for control |
|---|---|---|---|
| **MITES.** | | | |
| Silver mite (*Eriophyes oleivorus* Ashm.) | Branches, foliage, fruit | Dry lime and sulphur. Lime-sulphur 2 to 3 per cent. | As soon as the mites appear. |
| Six-spotted mite (*Tetranychus bimaculatus* Harv.). | Foliage | Same as for the silver mite | As soon as it appears. |
| Citrus red spider (*Tetranychus mytilaspidis* Riley). | Foliage and fruit | Lime-sulphur spray, 2 to 4 per cent. | When mites become destructive. |
| **KATYDID.** | | | |
| Katydid (*Microcentrum laurifolium* Linn.) | Eat holes in the young oranges. | Arsenical spray | Only in case large numbers appear. |
| **WHITE ANT.** | | | |
| Common termite (*Termes lucifugus* Rossi) | Roots | Carbon bisulphide around roots | When termites appear. |
| **THRIPS.** | | | |
| Greenhouse thrips (*Heliothrips hæmorrhoidalis* Bo.). | Foliage and fruit | Lime-sulphur, 1 to 80. Blackleaf 40, 1 to 1800. | As soon as presence is known. |
| Citrus thrips (*Euthrips citri* Moult.) | Foliage and fruit | Same as for greenhouse thrips | August and September. |
| **PLANT LICE.** | | | |
| Woolly citrus aphid (*Aphis cookii* Essig) | Foliage of orange | Carbolic acid emulsion 1 to 20. Blackleaf 40, 1 to 1600. | As soon as lice appear. |
| Melon aphis (*Aphis gossypii* Glover) | Foliage | Carbolic acid emulsion 1 to 20. Blackleaf 40, 1 to 1600. | As soon as lice appear. |
| Green citrus louse (*Macrosiphum citrifolii* Ashm.). | Foliage | Carbolic acid emulsion 1 to 20. Blackleaf 40, 1 to 1600. | As soon as lice appear. |
| Green peach aphid (*Myzus persicæ* Sulz.) | Foliage | Carbolic acid emulsion 1 to 20. Blackleaf 40, 1 to 1600. | As soon as lice appear. |
| Black citrus louse (*Toxoptera aurantiæ* Koch). | Foliage | Carbolic acid emulsion 1 to 20. Blackleaf 40, 1 to 1600. | As soon as lice appear. |
| **SCALE INSECTS.** | | | |
| Cottony cushion scale (*Icerya purchasi* Mask.). | Branches and foliage | Controlled by *Novius cardinalis* and *N. koebelei*. | Apply at State Insectary when pest becomes bad. |
| Citrus mealy bug (*Pseudococcus citri* Risso). | Foliage and fruit | Fumigation sched. No. 1. Carb. acid emul. 1 to 20. | November to February. |
| Long-tailed mealy bug (*Pseudococcus longispinus* Targ.). | Foliage and fruit | Fumigation sched. No. 1. Carb. acid emul. 1 to 20. | As soon as it appears. |

| | | | |
|---|---|---|---|
| Soft brown scale (*Coccus hesperidum* Linn.). | Tender branches and foliage. | Fumigation, ¾ schedule No. 1 | Whenever necessary. |
| Longulus scale (*Coccus elongatus* Sign.) | All branches and foliage | Fumigation, schedule No. ¾ | July 20 to August 31. |
| Frosted scale (*Eulecanium pruinosum* Coq.). | Branches | Not serious enough to warrant control. | |
| Hemispherical scale (*Saissetia hemisphærica* Targ.). | Branches and foliage | Fumigation, ¾ schedule No. 1 | September 1 to January 1. |
| Black scale (*Saissetia oleæ* Bern.) | Branches and foliage | Fumigation, ¾ schedule No. 1 | September 1 to January 1. |
| Orange Chionaspis (*Chionaspis citri* Comst.). | Branches and foliage | Fumigation, schedule No. 1 | When the scale appears. |
| Greedy scale (*Aspidiotus camelliæ* Sign.) | Foliage and fruit (tree ripes). | Not necessary | Any time. |
| Ivy scale (*Aspidiotus hederæ* Vall.) | Foliage and fruit (tree ripes, usually). | Not necessary | Any time. |
| Florida red scale (*Chrysomphalus aonidum* Linn.). | Branches, foliage, fruit | Fumigation, schedule No. 1 | When scale appears destructive. |
| Red scale (*Chrysomphalus aurantii* Mask.) | Branches, foliage, fruit | Fumigation, schedule No. 1 | When scale is a menace to crops. |
| Yellow scale (*Chrysomphalus citrinus* Coq.). | Foliage and fruit | Fumigation, schedule No. 1 | When it becomes menace to crop. |
| Purple scale (*Lepidosaphes beckii* Newm.) | Branches, foliage, fruit | Fumigation, schedule No. 1 | Whenever serious. |
| Glover's scale (*Lepidosaphes gloverii* Pack.). | Branches, foliage, fruit | Fumigation, schedule No. 1 | Whenever serious. (Not common.) |
| Chaff scale (*Parlatoria pergandii* Comst.) | Branches, foliage, fruit | Fumigation, schedule No. 1 | When it first appears. |
| **WHITE FLY.** | | | |
| Citrus white fly (*Aleyrodes citri* R. and H.). | Foliage | Fumigation, schedule No. 1 | When larvæ appear on leaves. |
| **MOTHS AND BUTTERFLY.** | | | |
| Variegated cut worm (*Peridroma margaritosa saucia* Hubn.). | Foliage | Tanglefoot bands. Arsenical sprays. | As soon as first worms appear. |
| Orange tortrix (*Tortrix citrana* Fern.) | Fruit of orange | Arsenical sprays | As soon as damage is noticed. |
| California orange dog (*Papilio zolicaon* Boisd.). | Foliage of orange | Arsenical sprays. Hand picking. | As soon as larvæ are discovered. |
| **BEETLES.** | | | |
| Western twelve-spotted cucumber beetle (*Diabrotica soror* Lec.). | Foliage | Arsenical sprays | As soon as destructive. |
| Fuller's rose beetle (*Aramigus fulleri* Horn.). | Foliage | Tanglefoot bands. Arsenical sprays. | When attacks are first noticed. |

FIG. 33.—Purple scale. *Lepidosaphes beckii* (Newm.), on leaf. (Essig, Bull. 2, C. Pom. Cl.)

FIG. 34.—Adult citrus white fly (*Aleyrodes citri* R. & H.). Enlarged fifteen times. After Quayle. Courtesy California Experiment Station.)

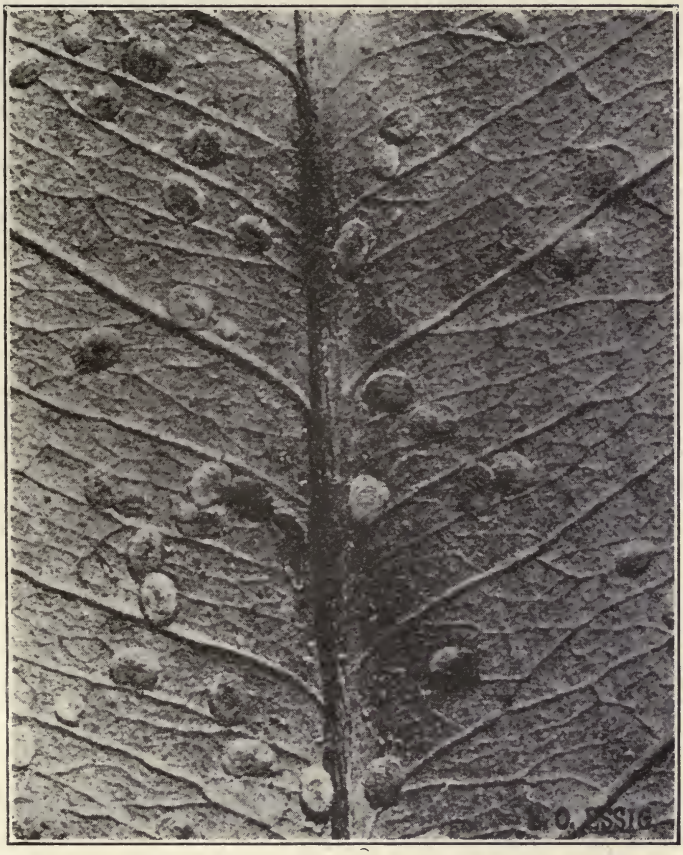


FIG. 35.—Larvæ and pupæ of the citrus white fly. (*Aleyrodes citri* R. & H.) on the under side of an orange leaf. Enlarged three times. (After Essig.)

## PREDACEOUS INSECTS PREYING UPON CITRUS PESTS.

| Predator | Pest preyed upon |
|---|---|
| **LACEWINGS.** | |
| Brown lacewing (*Sympherobius angustus* Bks.) | Mealy bugs, mites. |
| Green lacewing (*Chrysopa californica* Coq.) | Mealy bugs, plant lice, mites. |
| *Hemerobius pacificus* Bks. | Mites. |
| **LADYBIRD BEETLES.** | |
| *Hippodamia convergens* Guer. | Plant lice, young scale insects. |
| Two-stabbed ladybird beetle (*Chilocorus bivulnerus* Muls.) | Scale insects. |
| Steel-blue ladybird (*Orcus chalybeus* Boisd.) | Scale insects. |
| *Axion plagiatus* Oliv. | Scale insects. |
| *Axion pilatii* Muls. | Scale insects. |
| *Exochomus californicus* Casey | Scale insects, plant lice. |
| *Cryptogonus orbiculus* Schon. | Mealy bugs. |
| *Cryptolæmus montrouzieri* Muls. | Mealy bugs. |
| *Hyperaspis lateralis* Muls. | Mealy bugs and other scale insects. |
| *Scymnus sordidus* Horn. | Plant lice, mealy bugs, young armored scales. |
| *Scymnus guttulatus* Lec. | Mealy bugs. |
| *Scymnus nebulosus* Lec. | Mealy bugs, plant lice. |
| *Scymnus marginicollis* Mann. | Scale insects and plant lice. |
| *Stethorus vagans* Blackb. | Mites. |
| Vedalia (*Novius cardinalis* Muls.) | Cottony cushion scale. |
| *Novius kœbelei* Olliff. | Cottony cushion scale. |
| Black ladybird (*Rhizobius ventralis* Er.) | Black scale, mealy bugs. |
| **SYRPHID FLIES.** | |
| Large syrphid (*Lasiophthicus pyrastri* Linn.) | Plant lice. |
| American syrphid (*Syrphus americana* Wied.) | Plant lice. |
| Small syrphid (*Allograpta obliqua* Say) | Plant lice. |

FIG. 36.—Adult female of *Cryptolæmus montrouzieri* Muls. (Essig, P. C. Jr. Ent.)

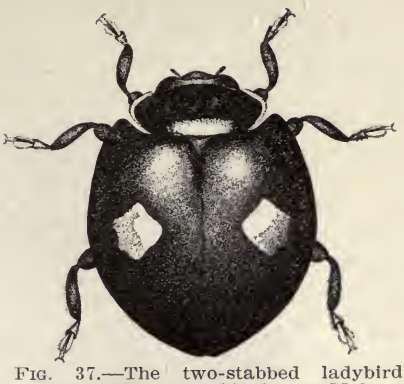

FIG. 37.—The two-stabbed ladybird beetle, *Chilocorus bivulnerus* Muls.

FIG. 38.—The vedalia, *Novius cardnalis* Muls.

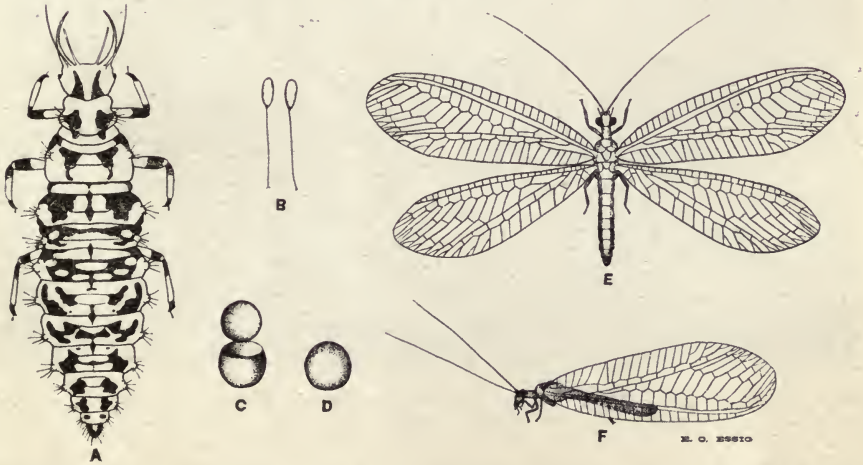


FIG. 39.—The green lacewing (*Chrysopa californica* Coq.). A, larva; B, eggs on the slender stalks; C, cocoon opened; D, cocoon closed; E and F, adult females. (Essig, P. C. Jr. Ent.)

FIG. 40.—Soft brown scale (*Coccus hesperidum* Linn.), showing exit holes of true parasites. (After Quayle. Courtesy Cal. Exp. Sta.)

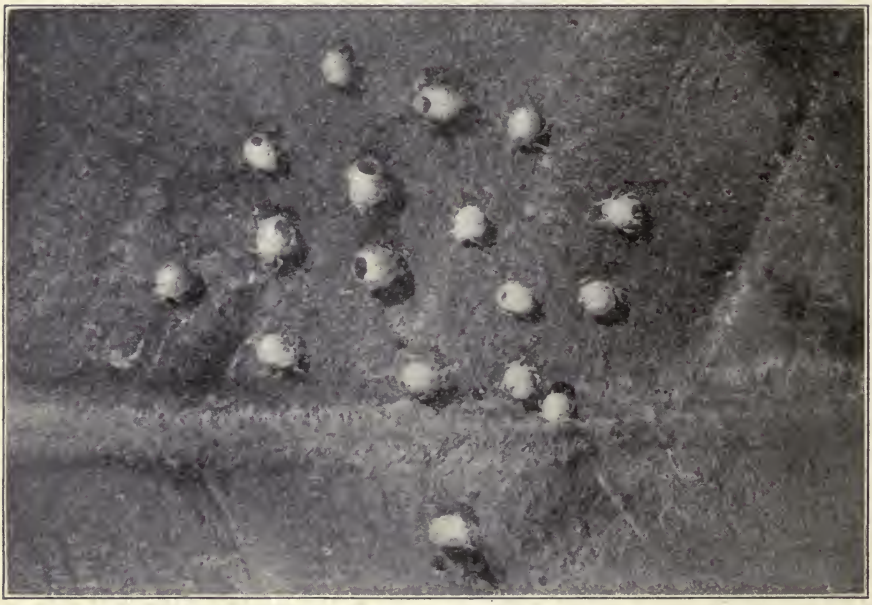

FIG. 41.—Mummied bodies of the citrus aphid (*Toxoptera aurantiæ* Koch), showing exit holes of the internal parasites. (Essig, P. C. Jr. Ent.)

## INTERNAL PARASITES PREYING UPON CITRUS PESTS.

| Parasite | Pest preyed upon |
|---|---|
| **HYMENOPTEROUS.** | |
| *Aphidius testaceipes* (Cress.) | Citrus aphids. |
| *Charips xanthopsis* (Ashm.) | Black citrus louse. |
| *Comys fusca* How. | Frosted scale. |
| *Encyrtus flavus* How. | Soft brown scale. |
| *Scutellista cyanea* Motsch. | Black and hemispherical scales. |
| *Chrysoplatycerus splendens* How. | Mealy bug. |
| *Cheiloneurus dactylopii* How. | Mealy bug. |
| *Tomocera californica* How. | Black scale. |
| *Aphycus flavus* How. | Soft brown scale. |
| *Aphycus immaculatus* How. | Red scale. |
| *Aspidiotiphagus citrinus* Craw. | Red, yellow, purple scales. |
| *Prospaltella aurantii* How. | Yellow and purple scales. |
| *Signiphora occidentalis* How. | Yellow scale. |
| *Aphelinus diaspidis* How. | Red scale. |
| *Coccophagus lunulatus* How. | Red scale. |
| *Coccophagus lecanii* (Fitch) | Soft brown scale. |
| *Eupelmus mirabilis* (Walsh) | Eggs of katydid. |
| **DIPTEROUS.** | |
| *Cryptochætum iceryæ* Will. | Cottony cushion scale. |
| *Leucopis bella* Loew. | Mealy bugs. |

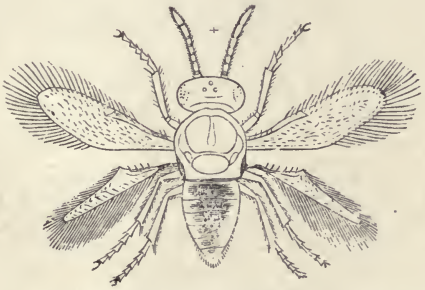

FIG. 42.—The purple scale parasite, *Aspidiotiphagus citrinus* Craw. (After Howard.)

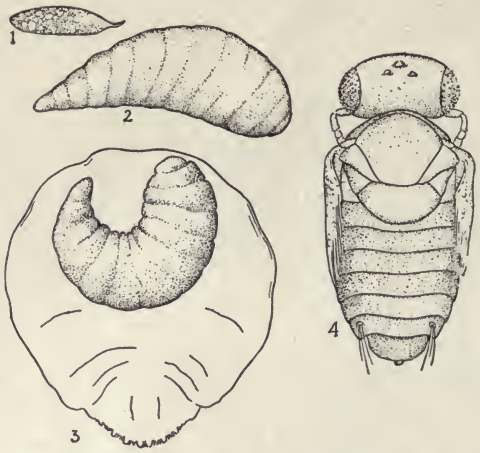


FIG. 43.—*Aspidiotiphagus citrinus* Craw. 1, egg; 2, larva; 3, larva within the body of a yellow scale; 4, pupa. Greatly enlarged. (After Quayle. Courtesy Cal. Exp. Sta.)

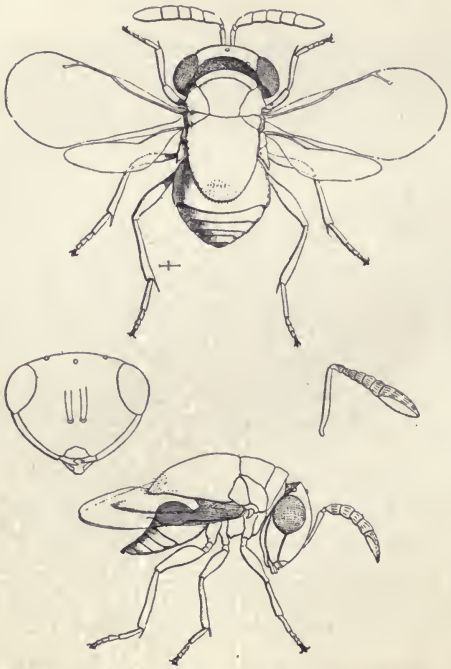

FIG. 44.—*Scutellista cyanea* Motsch. (After Howard.)

# SPRAYS.

For many years spraying was the only known method for the control of citrus pests, but the discovery of fumigation and the use of hydrocyanic gases has practically eliminated commercial spraying in the citrus orchards for injurious insects. Fungus diseases, however, are still to be controlled by spraying, including such fungicides as Bordeaux mixture and lime-sulphur.

Plant lice are controlled entirely by the use of contact sprays, chief of which are carbolic acid emulsion and tobacco decoction.

In a number of instances it has been found practical to control certain scale insects by the use of sprays. Young seed bed stock is usually dipped in resin wash or sprayed with an oil emulsion to kill young scale. It has been found that the carbolic acid emulsion is a cheap and ready means of controlling the citrus mealy bug.

Only the most important spray formulæ are given in this work:

**Bordeaux Mixture.**

| | |
|---|---|
| Unslaked lime | 4 pounds |
| Copper sulphate (bluestone) | 4 pounds |
| Water | 50 gallons |

The task of mixing these chemicals, where large quantities of the spray is used, is no small thing in itself. A great deal of study has been given to the construction of suitable mixing apparatus.

The first consideration is to get the materials high enough on a platform so that they can be easily and rapidly placed in the spraying tanks of the power machines. This is done by constructing at convenient places in the orchard, platforms large enough to hold a large box for slaking lime, a lime solution agitator, and a vat for dissolving bluestone. Such a platform is about 12 feet square and 4½ feet high. A large standpipe for filling the tanks is desirable, or the water must be pumped into the tank while the solutions are being added.

The lime is first slaked in a common vat for that purpose. It is necessary to keep the slaked lime agitated properly when it is being drawn off to mix with the bluestone in the spraying tank.

The bluestone vat contains slats, across the entire box or simply across one end. These slats must be low enough so that the bluestone, which is placed upon them in sacks, will be completely immersed in the water. This method admits quick dissolving of the bluestone, much more rapidly than if simply poured into the tank and stirred.

The lime and bluestone are mixed with a given amount of water so that the proper quantities of the resultant solutions can be measured so as to give the mixture the strength of the above formula.

The sieve used should be made of brass wire and contain twenty meshes to the inch.

This spray is used on such fungus diseases as wither-tip, brown rot, etc.

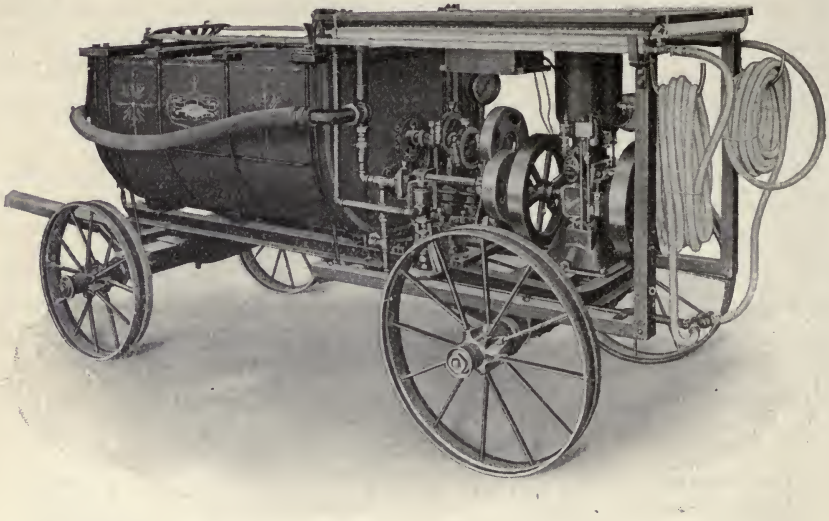

FIG. 46.—An excellent type of a power sprayer costing $350.00. (Courtesy Bean Spray Pump Co.)

### Bordeaux Paste.

1 pound of bluestone (copper sulphate) dissolved in one gallon of water in a wooden or earthen vessel. This can best be done by hanging it in a sack in the top of the water.
2 pounds of unslaked lime, slaked in about one half gallon of water. Some variation from these proportions may be made without greatly changing the value of the paste.

Stir together when cool, making a light blue mixture about the consistency of whitewash. If the mixture turns to some other color before being applied, it is an indication that something is wrong. Mix up fresh each day or two, as the mixed paste tends to deteriorate with age. It may be applied with a large brush as whitewash. A wash made of equal parts of lime and sulphur (self-boiled) is also being tried out. This may prove equally as good.

This paste is applied to the trunks of lemon trees which are affected with gum disease.

### Commercial Tobacco Extracts.

The extract containing two and three quarters per cent nicotine should be diluted to sixty parts of water. The extract containing forty per cent nicotine should be diluted from one to one thousand parts or one to fifteen hundred parts of water.

### Commercial Lime-Sulphur.

The commercial spray is a perfectly clear liquid, easy to handle and needing only to be properly diluted for use. It is usually sold in barrel lots. There are two common brands upon the market in California, sold under the trade names, "Rex" and "Ortho," though there are other sprays equally as good manufactured elsewhere.

For red spider on citrus trees this spray is applied as a two or three per cent solution.

### Carbolic Acid Emulsion.

| | |
|---|---|
| Whale oil soap | 40 pounds |
| Crude carbolic acid | 5 gallons |
| Water to mix | 40 gallons |

Dissolve the soap in hot water (the soap must be entirely dissolved); add the carbolic acid and heat to the boiling point for twenty minutes (reserve some water to add in case the mixture begins to boil over). For use add twenty gallons of water to every gallon of the above stock solution. The emulsion needs little or no agitation.

This spray is especially recommended for mealy bugs, but is also suitable for plant lice and soft brown scale. It is also a good contact insecticide for ants.

### Resin Wash.

Though not a true emulsion and fast losing prominence as a spray, this wash is included here because of its value as a spray and dip for plants with tender foliage.

| | |
|---|---|
| Resin | 10 pounds |
| Caustic soda (76 per cent) | 3 pounds |
| Fish oil | 1½ pounds |
| Water | 50 gallons |

Put oil, resin and a gallon of water in an iron kettle and heat until the resin is softened; add the lye (dissolved in a small amount of water) and stir thoroughly, after which add enough water to make fifty gallons of spraying material.

This wash is only effective for young scale insects, plant lice, or other soft-bodied insects.

### Lead Arsenate.

| | |
|---|---|
| No. 1. Commercially prepared. | |
| Lead arsenate (paste) | 6 to 8 pounds |
| Water | 100 gallons |
| No. 2. | |
| Arsenate of lead (powder) | 2 to 8 pounds |
| Water | 100 gallons |

*Preparation*—Simply dissolve the paste or powder in the required amount of water or in a small amount and add the remainder for use.

A poison spray for leaf-eating insects.

# DUSTS.

A number of valuable insecticides are applied dry, as dusts. They are easy to mix and handle, and are often of great service to the farmer and orchardist, especially in controlling red spiders or mites on citrus trees.

## Flowers of Sulphur.

For a number of years flowers of sulphur was used alone as a remedy for mites on citrus trees. It was distributed over the trees by hand or with a blower in the early morning when the foliage was damp, thus enabling it to adhere. The warm sunshine oxidizes the sulphur, the liberated sulphur-dioxide being the killing factor. Accordingly, sulphur is of little avail in the cool summer weather of the coast counties or during the winter months anywhere. However, in the warm interior districts this is still a very effective remedy for mites.

FIG. 45.—A power blower for applying dust sprays in orchards. About forty acres can be treated in one day with such a machine. It costs $115.00.

### Lime and Sulphur.

Even better than sulphur alone is hydrated lime and flowers of sulphur mixed in equal parts and blown upon the trees with a power machine, as is shown in Fig. 45. In the citrus orchards this is a very important method of controlling the citrus red spider (*Tetranychus mytilaspidis*) and the six-spotted or yellow mite (*Tetranychus bimaculatus*).

## TANGLEFOOT BANDS.

To prevent insects from crawling up the trunks of trees and plants sticky bands have been devised which have proven exceedingly successful in many instances.

Tree tanglefoot is a thick, sticky substance which, when applied as a band, remains moist for several weeks and is a very effective barrier against cankerworms, caterpillars, cutworms, Fuller's rose beetle and other crawling insects.

The material is put up in cans. It should be applied directly to the trunk of the tree several feet above the ground.

## *FUMIGATION.

Fumigation consists in the generation and uses of gases to kill destructive insect pests. Formerly such practices were limited to the uses of carbon bisulfid, sulphur dioxid and tobacco fumes. The use of hydrocyanic acid gas in citrus orchards has lately been so perfected as to become of very great importance, and has opened up a remarkable field in the control of orchard pests.

### HYDROCYANIC ACID GAS.

Hydrocyanic acid gas is generated by the addition of diluted sulphuric acid to sodium or potassium cyanide. The generation is made in an earthenware jar, the gas being confined in a fumigation house, or, if the work is being done in the orchard, in a tent thrown over the tree. For many years the methods of fumigation depended entirely upon each fumigator, there being no uniform or common procedure. The results of this early work so clearly showed the need of systematism

*From "Injurious and Beneficial Insects of California," The Monthly Bulletin of the State Commission of Horticulture, Vol. II, Nos. 1 and 2, 1913.

that the United States Department of Agriculture set experts to work out a reliable and uniform system of procedure. Dr. A. W. Morrill inaugurated our present system of marked tents and a system of dosage, which is known as "The Morrill System." This work was done in Florida. Later Mr. R. S. Woglum began operations in California and greatly perfected this system so as to make it at once practical and available to all the orchardists.

## TENTS.

**Shape.** In order to conform as near as practicable to the form of a tree, fumigation tents are made in the shape of an octagon (8-sided)

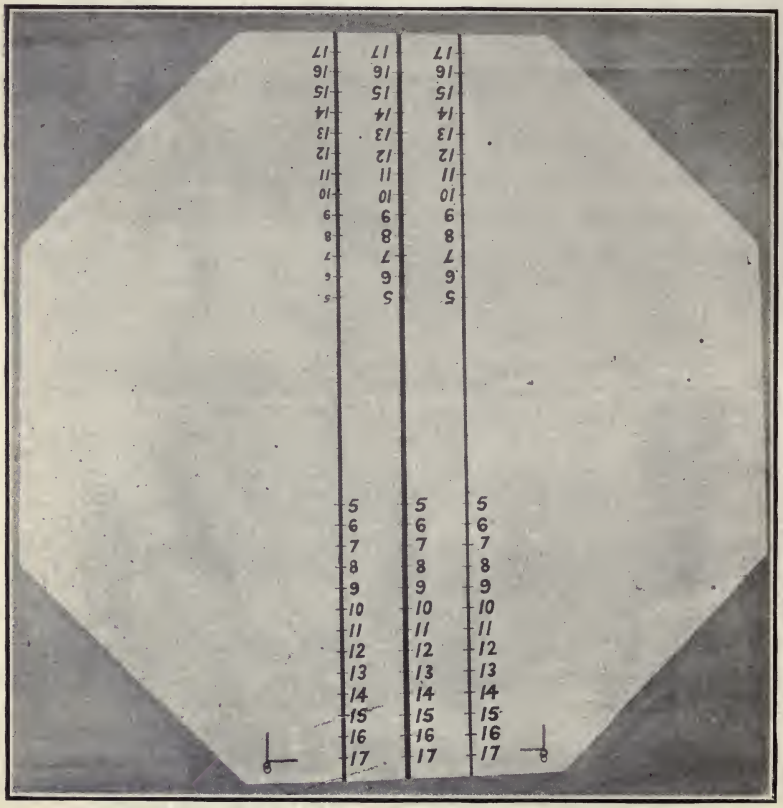


FIG. 47.—Showing shape and method of marking tent. (U. S. Dept. Agrcl.)

(Fig. 47). If the tents were square the corners would be a constant and unnecessary annoyance.

For small trees bell tents were formerly made by cutting the tents circular and sewing a strong hoop around the bottom. Such tents are seldom if ever used at the present time.

**Size.** The size of a tent naturally depends upon the size of the tree.

For young orchards a twenty-foot tent will serve until the trees are about four years old, and the tents can then be enlarged by simply sewing a border around the edges. This border might just as well be made of lighter and less expensive materials. In this way an orchard may be carried over until the ordinary orchard tents can be used. In fact many fumigators do use a large tent upon a small tree by placing a suitable square or triangular frame around the tree to support the tent or if the trees are strong enough to allow them to support the tents unaided.

FIG. 48.—Marked fumigating tent over tree. (After Pierce, P. C. Jr. Ent.)

For ordinary work forty-five-foot tents are commonly used and meet all requirements of a full grown orchard, except for unusually large trees, many of which require seventy or eighty-foot tents. It is customary, however, to use two or even three tents together when there is only an occasional large tree.

**Materials.** The life and nature of a fumigation outfit depends upon the quality and care of the tents. Many materials have been recommended and tried, army duck and drills of various weights being those most used. Special tight-woven drill tents were recommended by fumigating investigators, but these materials, though allowing but a small escape of gas, have not been able to stand the rough usage. After

several years of trial with the drills it is becoming the unanimous opinion of fumigators that by far the best all around tent material is the eight-ounce army duck. Though somewhat coarse and open it is able to hold the gas well and may be used almost twice as long as the drills.

Tents should be ordered a little larger to allow for shrinkage when dipped.

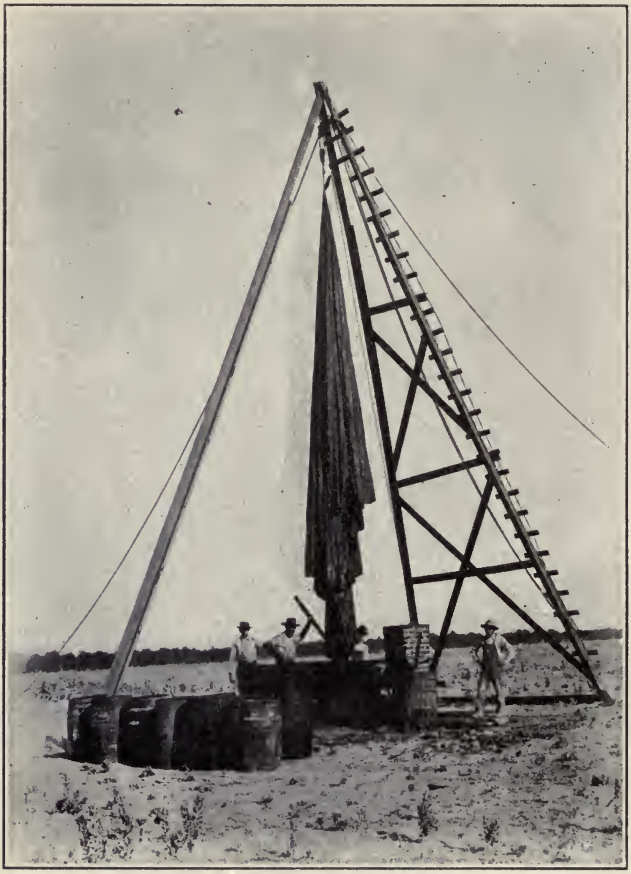

FIG. 49.—Apparatus for dipping tents in tannin to prevent mildew. (After Woglum.)

**Dipping.** To prevent moulding and rotting, new tents are usually treated in a tannin bath. A suitable outfit for this work is shown in Fig. 49.

The tank should have a capacity of from two hundred and fifty to three hundred gallons. Oakbark extract of tannin is used at the rate of one pound to every five gallons of water. Six or eight pounds of

tannin and the amount of water removed with the tent should be added after each is dipped.

The tannin solution should be brought to a boil and the tents immersed for half an hour, after which they are removed and spread out to dry.

A forty-five foot tent will shrink about one foot all around in dipping (allowing for some stretching by use afterwards).

The cost of dipping for tannin, fuel, labor, etc., amounts to about $1.20 to $1.50 outside of equipment.

**Marking.** Because of the shrinkage it is preferable to mark the tents after dipping.

The usual practice consists in marking three one and a half or two-inch parallel lines across the tent three feet apart. Three lines are made in preference to one, so that when the tent is put over the tree one of these lines will be sure to pass over the center. The measurements over the tree are ascertained by numbering each foot across the tent, beginning in the middle, and numbering each way, as shown in Fig. 47. The first four numbers are not designated because they are seldom if ever used. The cost of marking and stenciling the numbers averages about seventy-five cents a tent.

**Number for Outfit.** The ordinary fumigating outfit consists of from thirty to forty tents, a number which five men are capable of throwing and dosing at hourly intervals. An increase in apparatus or men for handling and dosing will naturally admit of an increase in this number.

**Care.** Greatest care should be exercised to prevent acid coming in contact with the tents, for every contact results in a large or small hole. Every day each tent should be carefully examined and all holes covered with sewed patches. Failure to follow these suggestions means poor and unsatisfactory work.

### CHEMICAL WAGONS.

Under the old system of scheduling and estimating, the dosage for every tree was made up at some central point in the orchard and distributed in carriers by hand. The new system of determining and making the dosage of every tree separately gave rise to the chemical cart or wagon, which carries a full supply of acid, cyanide and water in easily available shape.

The sulphuric acid should be kept in an earthenware or lead-lined container and drawn off through a rubber siphon or outlet. An ordinary keg or barrel with a faucet will hold the water and a tight box is all that is necessary for the cyanide. Dosage schedules, graduates, clamps, rubber gloves, scales and sufficient light complete the outfit. (Figs. 50, 51.)

**Acid Container.** For ordinary work a three, five or ten-gallon earthenware jar is sufficient. A lead lid for the top and a three fourths inch iron pipe inserted through a hole in the side near the bottom with a piece of pure rubber tubing six inches long and closed by a clamp is a cheap and practical device. Lead-lined tanks are more durable, but also much more expensive.

**Water Tank.** As there is three times as much water used as acid the water tank must necessarily be larger. For a hand cart a pickle keg is excellent, while a twenty-five or fifty-gallon barrel may be necessary for a large wagon. An extension pipe and faucet furnish the outlet which should be near that of the acid tank.

**Graduates.** The quantity of acid and water used depends entirely upon the amount of cyanide required for a dose. For every ounce of potassium cyanide one fluid ounce of sulphuric acid and three fluid

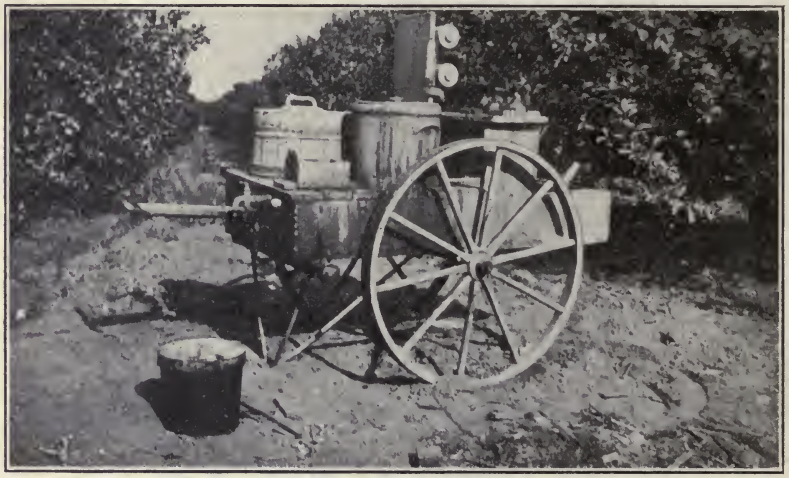

FIG. 50.—A cheap and satisfactory hand chemical cart. (Photo by Valle.)

ounces of water are used, while for sodium cyanide one and a half fluid ounces of sulphuric acid and two fluid ounces of water are used. As this is a fixed ratio in each case, graduates have been made to measure out the exact amount of the liquid required in the terms of the number of ounces of cyanide; for instance, if it required twelve ounces of sodium cyanide for a dose the acid graduate is so scaled that it would be filled to the twelve ounce line, which would mean eighteen liquid ounces and the water graduate to the twelve ounce line, which would be twenty-four liquid ounces. Such a scheme makes it unnecessary to make mental calculations and thus avoids mistakes.

## ACID GENERATORS.

Acid generators are earthenware pots usually made in gallon, two-gallon and three-gallon sizes and with or without lids (Fig. 52). The lid has long been recognized as a valuable adjunct to a generator by throwing the gas outward, thus preventing burnings directly above the generator. It also prevents the sputtering over of the acid due to the violent chemical reaction when the cyanide is added. So far there appears to be no lid manufactured which is entirely satisfactory, though nearly all fumigators prefer those on the market to the open generator. A suitable lid should be light and hinged so as to admit of easy emptying.

FIG. 51.—A specially constructed chemical wagon. (Photo by Fawcett.)

The two-gallon generator is more generally used because it more nearly meets the requirements of large and small doses. Care should be exercised not to fill a single pot more than one third full of acid and water before the cyanide is added as the contents may boil over and much of it be wasted. For large doses use two or more generators to a tree. To prevent unnecessary sputtering, especially when open generators are used, small cheap paper bags are excellent to contain the cyanide when it is dropped into the acid.

### MEASURING THE TENTS.

The air space of the tents is determined by a schedule based upon the cubical contents which in actual field operations is determined by the distances over and around the tent when it covers a tree. The distance over is easily ascertained by the marked lines across the tent—the sum of the two figures nearest the ground being taken. The distance

FIG. 52.—Acid generators showing residue remaining because of careless emptying. (After Pierce, P. C. Jr. Ent.)

around is often paced, but careful fumigators use a tapeline, which is certainly the only procedure to be recommended. The tapeline should be numbered in feet on both sides, the numbering of each side being opposite so as to admit of the use of either end without subtraction. A small, light snap is usually sewed to each end, to be fastened to the ring at the top of a short iron pin stuck in the ground to hold the loose end while the tape is carried around the tent.

### DOSAGE SCHEDULES.

These schedules are printed on fairly stiff paper so that they may be tacked upon a board for the use of the cyanide man. The figures are black and large enough to be plainly seen by the light of a torch or lantern on the darkest night. Half and quarter ounces are omitted, because of the difficulty in reading the small fractions at night and because few scales are made to register these small amounts accurately.

All less than half ounces are placed in the lower figure, while half ounces or over are placed in the next higher figure. A more convenient way of fixing up the schedule is to have a cylinder made of zinc, with a narrow slot, the width of a row of figures, covered by a glass, and a wooden roller on the inside, similar to a rolling pin. Each end of the cylinder is closed by a cap with a hole in the center, in which turns the handles of the wooden roller. The chart or schedule is attached to the roller so as to revolve in the cylinder. The figures of the distances around are pasted along the top of the slot to conform with the like numbers on the schedule. In finding the dosage one has only to turn the roller until the distance over shows at the left-hand end of the slot; the figure at the top of the slot shows the distance around. In this way, the chart is kept perfectly dry and bright and the possibilities of making a mistake are reduced to a minimum. This arrangement was first invented by Mr. C. E. McFadden, Fullerton, California, who used it on all of his chemical carts.

### MISCELLANEOUS EQUIPMENT.

Rubber gloves for handling the acid graduate and generators, pure rubber tubing for drawing off the acid, acid clamps or cut-offs to control the flow, a pair of scales registering ounces, thermometer and good lights are as necessary as any of the other equipment.

### CHEMICALS.

The chemicals used for generating hydrocyanic acid gas in fumigating work are potassium or sodium cyanide, commercial sulphuric acid and water. The cyanide is usually handled in the 200-pound cases and the acid in steel drums weighing from 1,200 to 2,000 pounds.

**Cyanide.** For many years potassium cyanide 98-99 per cent pure was thought to be the best and only reliable source of hydrocyanic acid gas. It was formerly used to the exclusion of all others, and is still preferred by many who do not wish to add the injurious residue of sodium cyanide to their soil, and also by those who do not see enough advantages in sodium cyanide to warrant a change.

There are two grades of sodium cyanide: the 98-100 per cent pure, which is totally unfit for fumigation purposes because of the impurities it contains, and the pure 129-130 per cent sodium cyanide, which is used almost exclusively for fumigation work. This product, though somewhat more expensive than the potasisum cyanide per pound, has much more available hydrocyanic acid gas and consequently a smaller amount is necessary, which is enough smaller to make the cost of dosage less than that for potassium cyanide, and is therefore fast displacing it. Much has been said for and against the sodium cyanide relative to the burning of fruit and foliage, but this is still an unsettled point.

Both of the cyanides are good and reliable, and the deciding features will probably always be the supply available and the price.

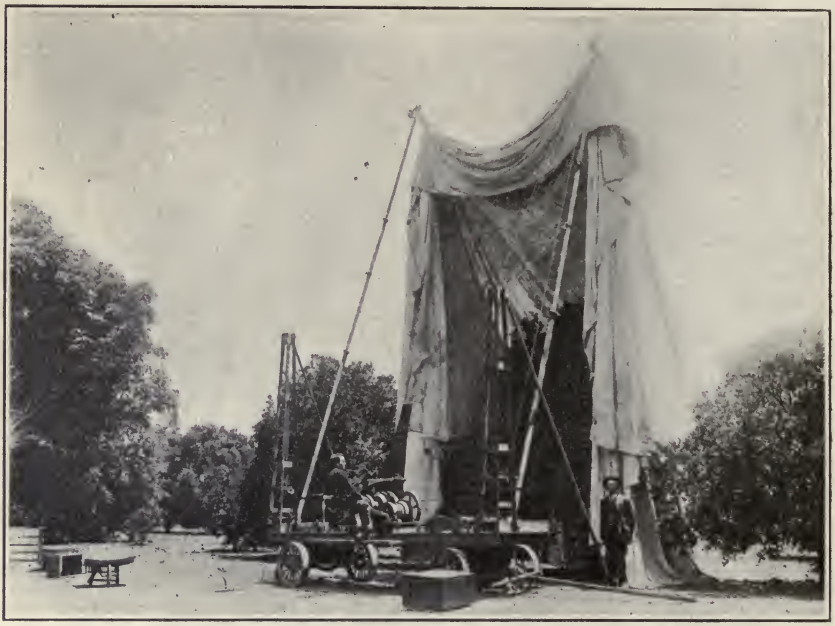

FIG. 53.—The McFadden tent-hoisting machine. (After Woglum.)

**Sulphuric Acid.** Fumigating sulphuric acid has a specific gravity of about 66 degrees Baumé, often containing traces of nitric acid and arsenic, lead or zinc. It has been the current belief that nitric acid especially caused the burning of the fruit and foliage so often the results of fumigating work, but R. S. Woglum in Bull. No. 90, Part I, page 42, U. S. Dept. Agrcl., Bureau Entomology, states that this is an erroneous belief. It should always be the aim of every fruit grower to get good grades of sulphuric acid, which is not at all difficult at the present time.

### CHEMICAL PROPORTIONS.

| | | |
|---|---|---|
| **Potassium Cyanide:** | | |
| Potassium cyanide | 1 | ounce |
| Sulphuric acid | 1 | fluid ounce |
| Water | 3 | fluid ounces |
| **Sodium Cyanide:** | | |
| Sodium cyanide | 1 | ounce |
| Sulphuric acid | 1½ | fluid ounces |
| Water | 2 | fluid ounces |

## METHODS OF PROCEDURE.

For an outfit of thirty or thirty-five tents five men are required to operate to an advantage. Two men pull the tents and kick in the edges around the bottom. One man, the taper, takes the measurements of the tree and calls them off to the man who weighs out the cyanide. After determining the dosage this man also empties the generators from the row just finished and has them ready for the next trees by the time the chemical cart arrives. The man who weighs the cyanide determines the dose on the schedule from the measurements called out by the man who measures the tents. The cyanide man also lifts the tent so that the last man who measures out the acid and water in the generators may place them well under the tree, after which the cyanide is added. In no case should the acid man touch the tents. While the chemical men are dosing one tree the taper is getting the measurements for the next tree ready in advance. In brief, the procedure is as follows: putting the tents over the trees, measuring and dosing. The string of thirty tents can be easily dosed within forty-five minutes or an hour. Methods of procedure vary considerably, the above being general.

For extra large trees a special tent-hoisting apparatus (Fig. 53) has been devised by Mr. C. E. McFadden, with which a 70 or 80-foot tent can be easily and quickly put over the largest citrus trees.

## DOSAGE.

The amount of cyanide used depends upon the pest to be treated. Accordingly several schedules (Figs. 54, 55) have been made, based upon dosage schedule No. 1 for purple or red scale made by R. S. Woglum. This dosage consists of one and a half ounces of potassium cyanide to every one hundred cubic feet of air space. The schedule dosage for black scale usually consists of three fourths of schedule No. 1 and is designated dosage schedule No. $\frac{3}{4}$.

If sodium cyanide is used the dosages are reduced 25 per cent.

**Black Scale.** Either dosage schedule No. $\frac{3}{4}$ or $\frac{1}{2}$ for potassium cyanide or $\frac{1}{2}$ for sodium cyanide. The smaller dosage is recommended only where there is an even hatch of very young scale insects.

**Purple, Red, Yellow Scale.** Use dosage schedule No. 1 for potassium cyanide and No. $\frac{3}{4}$ for sodium cyanide.

**Mealy Bug.** The same dosage as for black scale gives almost as good results as the heavier doses.

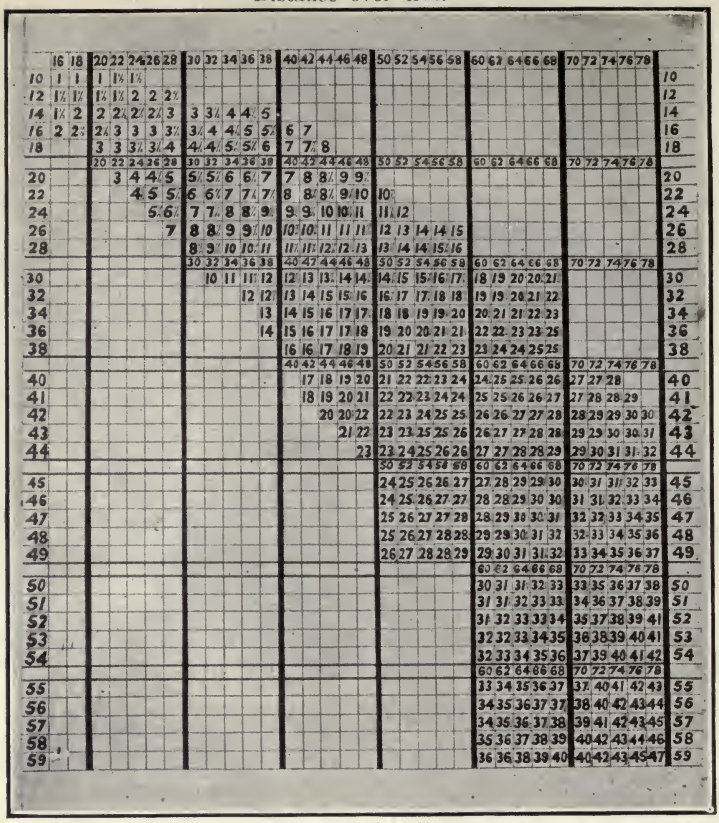


FIG. 54.—Schedule No. 1. The first few dosages should be doubled. (U. S. Dept. Agrcl.)

## LENGTH OF EXPOSURE.

The time required to complete the generation of the gas is not long, but it is advisable to leave the tents upon the trees for at least forty-five minutes after the dosage is placed under the tent. Some prefer thirty minutes, while others insist upon a full hour.

## TIME OF OPERATION.

For red, purple and yellow scale fumigation work is usually done during the winter or spring months. If black scale is present the time of operation covers the period from the middle of August to the middle of January, depending somewhat upon the individual locality.

## TEMPERATURE.

To avoid the heat of the sun, fumigation is ordinarily done during the night, when the atmosphere is cool. Cloudy cool days may admit of

some work, but all day operations are liable to cause severe burnings of fruit and foliage.

Excessive cold is also liable to cause disastrous results. Keep a thermometer on the wagon and do not operate under the following conditions: when the temperature is 70 degrees Fahr. or more above zero or when it is 36 degrees Fahr. or less. This latter temperature should be carefully avoided, especially upon damp or wet nights.

Hot, electric winds also tend to produce severe burning, and all work should be suspended on nights they are blowing.

Orchards previously sprayed with Bordeaux mixture should not be fumigated, as there results a chemical reaction which is exceedingly damaging to the fruit and foliage.

VENTURA COUNTY HORTICULTURAL COMMISSIONER
E. O. ESSIG

**FUMIGATING SCHEDULE FOR BLACK SCALE**
**SODIUM CYANIDE**
DISTANCE AROUND, IN FEET

DISTANCE OVER, IN FEET

| | 16 | 18 | 20 | 22 | 24 | 26 | 28 | 30 | 32 | 34 | 36 | 38 | 40 | 42 | 44 | 46 | 48 | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 10 | 1 | 1 | 1 | 1 | 1 | | | | | | | | | | | | | | | | | | | | | | 10 |
| 12 | 1 | 1 | 2 | 2 | 2 | 2 | | | | | | | | | | | | | | | | | | | | | 12 |
| 14 | 2 | 2 | 2 | 2 | 2 | 2 | 3 | 3 | 3 | 3 | 3 | 4 | | | | | | | | | | | | | | | 14 |
| 16 | 2 | 2 | 2 | 2 | 3 | 3 | 3 | 3 | 3 | 4 | 4 | 4 | 4 | 4 | | | | | | | | | | | | | 16 |
| 18 | 2 | 2 | 2 | 3 | 3 | 3 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 5 | | | | | | | | | | | | | 18 |
| | | | 20 | 22 | 24 | 26 | 28 | 30 | 32 | 34 | 36 | 38 | 40 | 42 | 44 | 46 | 48 | 50 | 52 | 54 | 56 | 58 | 60 | | | | |
| 20 | | | 2 | 3 | 3 | 4 | 4 | 4 | 4 | 4 | 4 | 5 | 5 | 5 | 5 | 5 | 6 | 6 | | | | | | | | | 20 |
| 22 | | | | | 4 | 4 | 4 | 4 | 4 | 4 | 5 | 5 | 5 | 5 | 6 | 6 | 6 | 6 | | | | | | | | | 22 |
| 24 | | | | | | 4 | 4 | 4 | 5 | 5 | 5 | 5 | 6 | 6 | 6 | 6 | 7 | 7 | | | | | | | | | 24 |
| 26 | | | | | | | 4 | 5 | 5 | 5 | 5 | 6 | 6 | 6 | 6 | 7 | 8 | 8 | 8 | 8 | 8 | 8 | | | | | 26 |
| 28 | | | | | | | | 5 | 5 | 6 | 6 | 6 | 6 | 7 | 7 | 8 | 8 | 8 | 8 | 8 | 9 | 9 | | | | | 28 |
| | | | | | | | | 30 | 32 | 34 | 36 | 38 | 40 | 42 | 44 | 46 | 48 | 50 | 52 | 54 | 56 | 58 | 60 | 62 | 64 | 66 | 68 |
| 30 | | | | | | | | 5 | 6 | 6 | 6 | 7 | 7 | 8 | 8 | 8 | 8 | 8 | 8 | 9 | 10 | 11 | 11 | 11 | 11 | 12 | 12 | 30 |
| 32 | | | | | | | | | | | 7 | 8 | 8 | 8 | 8 | 9 | 9 | 9 | 10 | 10 | 11 | 11 | 11 | 11 | 12 | 12 | 13 | 32 |
| 34 | | | | | | | | | | | | 8 | 8 | 8 | 9 | 10 | 10 | 11 | 11 | 11 | 11 | 11 | 12 | 12 | 13 | 13 | 13 | 34 |
| 36 | | | | | | | | | | | | 8 | 8 | 9 | 10 | 10 | 11 | 11 | 11 | 12 | 13 | 13 | 13 | 13 | 14 | 14 | 36 |
| 38 | | | | | | | | | | | | | 9 | 9 | 10 | 11 | 11 | 11 | 12 | 12 | 13 | 13 | 13 | 14 | 14 | 14 | 15 | 38 |
| | | | | | | | | | | | | | 40 | 42 | 44 | 46 | 48 | 50 | 52 | 54 | 56 | 58 | 60 | 62 | 64 | 66 | 68 | |
| 40 | | | | | | | | | | | | | 9 | 10 | 11 | 11 | 11 | 11 | 12 | 13 | 13 | 14 | 14 | 14 | 15 | 15 | 15 | 40 |
| 41 | | | | | | | | | | | | | | 11 | 11 | 11 | 11 | 12 | 13 | 13 | 14 | 14 | 14 | 15 | 15 | 15 | 16 | 42 |
| 42 | | | | | | | | | | | | | | | 11 | 11 | 12 | 13 | 13 | 14 | 14 | 14 | 15 | 15 | 15 | 16 | 16 | 44 |
| 43 | | | | | | | | | | | | | | | | 12 | 13 | 13 | 14 | 14 | 14 | 15 | 15 | 15 | 16 | 16 | 17 | 46 |
| 44 | | | | | | | | | | | | | | | | | | 13 | 14 | 14 | 14 | 15 | 15 | 15 | 16 | 17 | 17 | 48 |
| | | | | | | | | | | | | | | | | | | 50 | 52 | 54 | 56 | 58 | 60 | 62 | 64 | 66 | 68 | |
| 45 | | | | | | | | | | | | | | | | | | 13 | 14 | 14 | 15 | 15 | 15 | 16 | 17 | 17 | 17 | 50 |
| 46 | | | | | | | | | | | | | | | | | | 14 | 14 | 15 | 15 | 15 | 16 | 17 | 17 | 17 | 17 | 52 |
| 47 | | | | | | | | | | | | | | | | | | 14 | 14 | 15 | 15 | 16 | 17 | 17 | 17 | 17 | 18 | 54 |
| 48 | | | | | | | | | | | | | | | | | | 14 | 15 | 15 | 16 | 17 | 17 | 17 | 17 | 18 | 18 | 56 |
| 49 | | | | | | | | | | | | | | | | | | 14 | 15 | 16 | 16 | 17 | 17 | 17 | 17 | 18 | 19 | 58 |

NOTE.—Quarter and half ounces are omitted to make the schedule more practical for field conditions.
Proportions for mixing chemicals—Sodium Cyanide 1, Sulphuric Acid 1½, Water 2.

FIG. 55.—Dosage schedule No. ½ for black scale using sodium cyanide as prepared by Woglum. (Essig, P. C. Jr. Ent.)

## BUYING MATERIALS.

Fumigating acid and cyanide are usually bought in large lots by the fumigating contractor, the various associations, the counties and large orchard companies who are able to get the benefits of a much reduced

price. Until within the last few years the owner of a small orchard was not thus benefited unless the association to which he belonged or the county bought his materials. A co-operative company in the southern part of the State composed of the citrus growers themselves and known as the Fruit Growers' Supply Company, now gives its members the advantage of the prices obtained by making large purchases.

### BLOCK FUMIGATION.

The spread of scale insects in citrus orchards is very rapid, and under ordinary methods of fumigation, where only part of a district is treated each year, there is always a source of re-infestation from the trees which have not been fumigated for from one to several years. To eliminate this condition it is exceedingly desirable to fumigate large blocks or tracts of orchards the same year and thus place each upon the same basis. This is known as block fumigation and should be encouraged in every possible way, as it has great advantages over the usual haphazard fumigation of a district. All citrus growers should possess "Insects of California," Monthly Bulletin, State Commission Horticulture, Vol. II, 1913, No. 1-2, which is mailed free on application.

## DECADENCE OF CITRUS GROVES.

There has been no little discussion of late regarding deterioration of our citrus trees. The condition of some of our groves and the fact that increase of production does not keep pace with the increase in planting lends some apparent color to this contention. Yet we know that in Europe trees a century old are still vigorous and productive. Some of our oldest orchards in California have lost none of their health or productiveness. It has been suggested that our Washington Navels, in their developed excellence, have yielded some of their strength and vitality, and so may deteriorate while yet young; yet there are old Washington Navel trees that still show a maximum of vigor and productivity.

### The Real Facts.

We must remember that our citrus trees are marvelous producers; they know no rest season—no off years. Does it not stand to reason then that they must have the very best care and attention? If they are suffering from insufficient food or water; if the soil is hard and compact so that aeration is impossible; if they rest on impervious hardpan, then what wonder if they show decline or utterly succumb. In

such cases would it not be more correct to apply the term "decadence" to the manager or management than to the citrus trees? If our groves are failing in vigor then we should cast about and look sharply to the care which they are receiving. Is the soil rich in fertility; is there always abundant moisture; is aeration perfect; is there no show of hardpan or cemented subsoil; is there no disease, either fungoid, physiological or insect attack? If the orchardist can answer "no" to all these questions, then I believe he can give an emphatic "no" to any question of decadence. I saw lemon trees in Sicily said to be one hundred or two hundred years old. There they do not force their trees and expect little or no fruit for the first eight years. The famous orange grove of Mr. N. W. Blanchard of Santa Paula did not produce till eleven years old, since which time it has been an enormous producer and the trees have shown no decline of vigor.

## SPECIES AND VARIETIES OF CITRUS TREES.

Citrus trees belong to the family *Rutaceæ*, which includes our American prickly ash and hop tree. The genus *Citrus* comprises the orange,

FIG. 56.—Branch and fruit of *Citrus trifoliata*. Half size. (After Lelong.)

lemon, citron, pomelo, lime, etc. They are aromatic, glandular, shrubs or trees, usually thorny, leaves alternate, with petioles more or less

winged, compound though usually unifoliate; the joint between petiole and leaf shows that the apparent simple leaf is really compound; in one species trifoliate; flowers, pink or white, sweet-scented, hermaphrodite, calyx cupulate, three to five toothed; petals, four to eight, linear oblong imbricated in the bud; stamens, twenty to sixty, rarely only five; filaments more or less united; ovary compound, with five to many united carpals, one style and stigma, ovules, five to eight in each carpal in two rows; fruit a berry, spherical, oblong or pear-shaped with thick leathery rind containing numerous oil cells, pulp, juicy, aromatic; juice contained in curiously formed sacs, the form possessing possibly specific importance. Supposed origin of this genus is Cochin China or the Malayan Islands.

**Citrus trifoliata** Linn.

In its trifoliate deciduous foliage this species from Japan is peculiar. It is a shrub or small tree, very thorny (Fig. 56) with spherical yellow fruit and valuable commercially only as a hedge plant and for stock on which to bud the commercial orange and lemon. It is thought to dwarf the latter and may be more hardy than other stock. As previously stated, sour stock is now thought to be greatly preferable. It endures more cold, and so Dr. H. J. Webber has originated hybrids between this and the orange in hope of securing the frost resistance of the trifoliata and something of the excellence of the orange.

**Citrus aurantium** Linn. var. **amara** Linn.

This orange, known as *Bigaradia* (sour or bitter orange), also the Seville orange, is thought to be the original of all our oranges. The leaf is broadly winged, the flowers sweet-scented and the fruit spherical. It was brought early to Florida by the Spaniards and ran wild. The fruit (Fig. 57) is too bitter and sour for commercial purposes, but is sometimes used for marmalade. The seeds are large and prized, as the seedlings are thought by some to be more hardy and vigorous than are those from other seeds, and it is also said to stand neglect better, and to be more resistant to gum diseases. If the stock does influence the scion or bud, it is not obvious in this case, as the fruit seems not inferior. Mr. Lelong thought the *Bigaradia* inferior as stock to the sweet orange, for he says: "The trunks are not as large as those on sweet stock and show less expansion of root system." Our best authorities today favor strongly sour orange stock. There is considerable variation in these sour oranges. Lelong mentioned ten marked strains. Dr. Webber says there are only two, the bitter orange, prized as stock for budding, and the bitter-sweet, which is more pleasing to the taste. It is claimed by some that this is a well marked species, and the fact

that its peculiar sourness and bitter flavor persists would seem to sustain this contention. It is, however, very similar to the sweet orange. Dr. G. Harold Powell informs me that the stock of the bitter orange is universally used in lemon growing in Italy.

FIG. 57.—The sour or bitter orange (*Citrus aurantium* var. *amara* Linn. (After Lelong.)

**Citrus aurantium** Linn. var. **sinensis** Engler.

This is our common sweet orange and includes all the subvarieties so familiar to us. These subvarieties are often as marked as the variety itself. Its excellence and commercial importance makes it a great favorite, and so it is much grown and subject to varied care and treatment. This is doubtless the cause in great part of its many variations. Unaided nature has given us the superb navel orange. Does this not show that the orange is susceptible to change and improvement, in short, to marked bud variation? We believe we are safe in saying that the skillful breeder has great opportunity to create an orange that may greatly distance in excellence and productivity any yet produced.

The leaves of the sweet orange are oblong and pointed, petiole nar-

FIG. 58.—The Washington navel orange. Reduced. (After Lelong.)

rowly winged, fruit of varying color—yellow to orange—size and form from spherical to oblong, pulp when ripe, sweet and delicious. The seeds are large and much valued for planting. The tree is from twenty to forty feet in height.

### The Washington Navel Orange.

(Fig. 58.)

The most prized and excellent variety in California is the Washington navel. This in its perfection is at present certainly incomparable, not only as an orange, but as a fruit. The peculiar scar at the blossom or calyx end, and the fact that it was brought to Washington from Bahia, Brazil, by the Department of Agriculture in 1870, has given it the name of Washington navel. Two trees were brought from Washington, D. C., to Riverside, California, and thus a second name—Riverside navel. From these two trees buds have been taken in profusion, and thus our "King of Oranges" is now widely distributed, keenly relished and in great demand. The navel is the unmistakable mark, though occasionally found in other kinds of oranges and very rarely in lemons. This navel seems to be like a proliferous rose where the stem pushes through the flower and bears a second rose. Some wild flowers (*Salvia*) exhibit the same peculiarity. Here the second orange simply reaches the surface, though occasionally it pushes up partly through the rind, and rarely we have a second orange surmounting the fruit. The orange is seedless, which may be due to the fact that this second fruit prevents the pollen threads from pushing through to fecundate the seeds. The pollen being useless, nature has robbed the navel bloom of this product. Occasionally, although very rarely, pollen from other sources is effective and we have seeds, even in the navel. This fact suggests that in the near future all our citrus fruits will be rid of seeds. This navel orange is large, highly colored, pulp luscious, very sweet, flavor incomparable. It will always be a favorite. The tree is a profuse bearer, and of course must have most generous treatment. Decadent care will result in decadent trees.

An inferior navel, both in tree and fruit, is known as the Australian navel. Some think it is merely a sport of the Washington navel, while others think it is distinct It is a shy bearer and produces a coarse, undesirable fruit.

The Washington navel is not ready for the market in southern California till January, though often shipped for the holiday trade and may last, not greatly impaired in excellence, till July. In northern California it ripens earlier. In Florida this variety is a shy bearer and does not give the satisfaction that it does in Arizona and California. As remarked above, other varieties occasionally exhibit the navel cicatrix.

### Valencia Late.

This orange, also known as Hart's Late and Hart's Tardiff, is second in importance only to the navel. It is the only commercial summer orange in the world. It reaches maturity in May and increases in

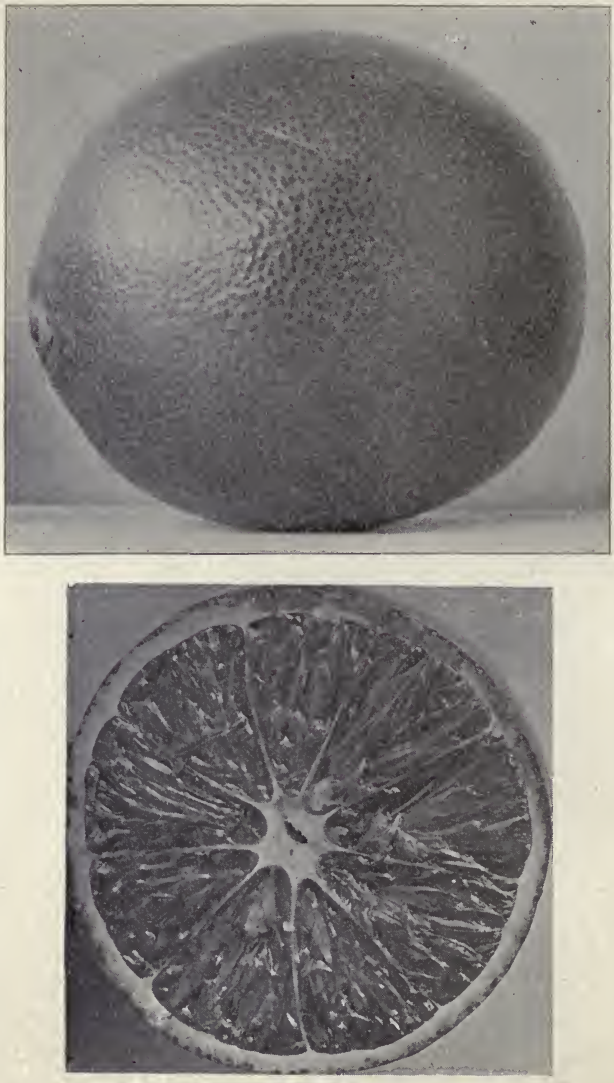

FIG. 59.—Valencia late. (After Lelong.)

perfection until late November. Like the navel, it is very productive, has a smooth skin, melting pulp, is nearly seedless, and is a very superior fruit. In color it is inferior to the navel. Sometimes the

green color returns, after the fruit yellows. In California it is now deservedly a great favorite with the growers, as it is everywhere with the consumers. It has of late years in many sections of California rivalled the navel in numbers planted. Without doubt, it is very wise to plant these two varieties in about equal numbers, giving the navel possibly in some sections somewhat the advantage. For the commercial orchard no other subvarieties are thought by many of our best citrus growers to be worthy of attention.

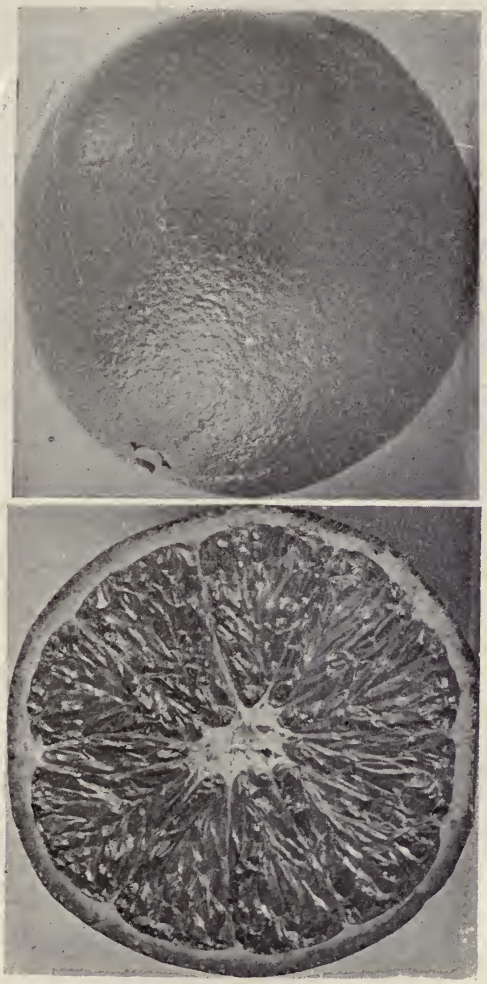

FIG. 60.—Thompson's improved navel. Reduced. (After Lelong.)

### Thompson's Improved Navel.

This is strikingly like the Washington navel, but has a very thin, smooth skin and is exceedingly beautiful. It does not equal the Wash-

ington navel in quality. It is doubtless simply a sport of the Washington navel, and is able to bequeath its desirable characteristics to its budded descendents.

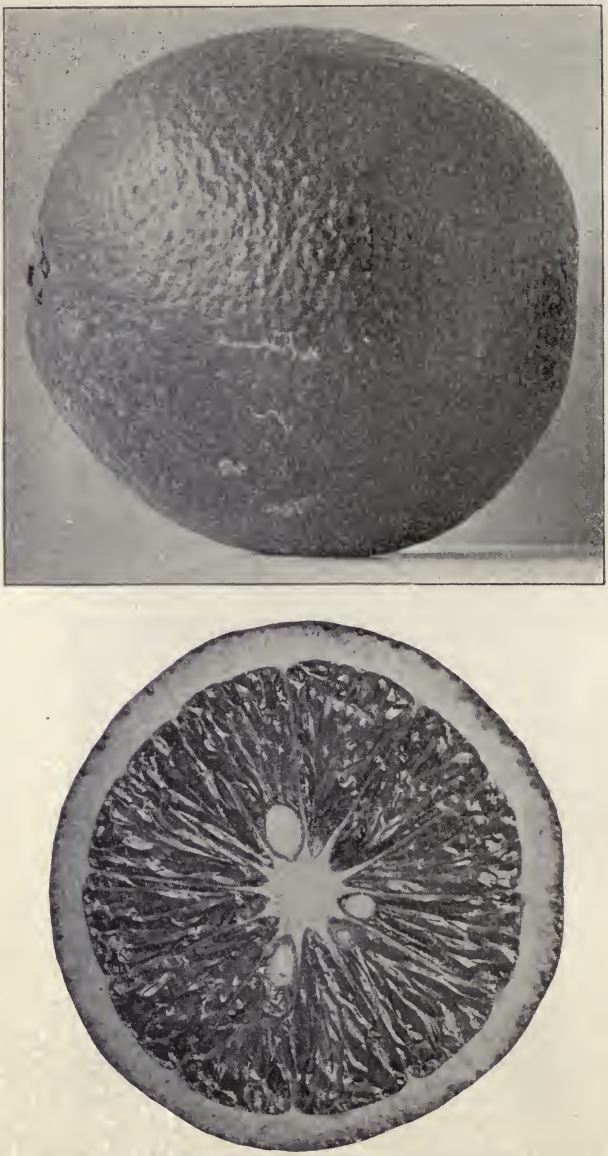

FIG. 61.—Jaffa orange. Natural size. (After Lelong.)

### Other Subvarieties.

There are many other oranges that have real merit and would be worthy of consideration in planting, except that the ones mentioned above are so much superior.

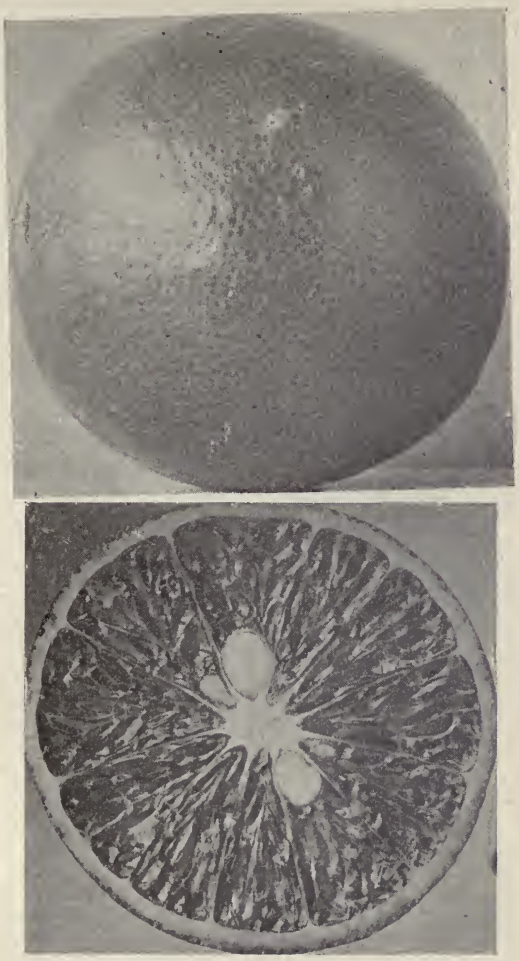

FIG. 62.—Paper rind St. Michael. Natural size. (After Lelong.)

**Seedlings.**

These secured without the labor of budding are of course cheaper, but they are correspondingly less valuable. The fruit is small, the trees very tall, so that picking is expensive, and yet these seedling orchards are often very profitable. Usually, however, they are budded over to more desirable kinds, but many possessors of such orchards think them too profitable to make this wise. Seedling trees often bear enormous crops.

**Homosassa.**

This orange originated in Florida, where it is a favorite. It is large, yellowish, pulp delicious, acidity moderate, sweetness marked. The season in Florida is from December to February, the usual time for fruiting in that state. It is rarely seen in California.

**Jaffa.** (Fig. 61.)

This beautiful orange comes from the Holy Land. It is very juicy with melting pulp. Had we not such varieties as the navel and Valencia, this beautiful, smooth skinned orange would be more frequently planted; however, it is sparingly planted here in California, and is much prized.

**Paper Rind St. Michael.** (Fig. 62.)

This orange has been much grown in California. The blending of acidity and sweetness, its delicious pulp and superior quality has secured for it many friends. We have enjoyed them greatly on our table and can say that it is not that we love this less, but the navel and Valencia more.

FIG. 63.—Dancy tangerine. Natural size. (After Lelong.)

**Mediterranean Sweet.**

This orange is well named, as the pulp is deliciously sweet and it is one of the Mediterranean subvarieties. The fruit is large and the tree a good producer, and it is one of the late varieties. In the past it was largely planted in California, but not so at the present time.

**The Blood Orange.**

These, from their very deeply colored pulp, are really unique and so are often thought desirable. The Malta and Ruby Bloods are the varieties most planted in California. They are small, but very juicy and sweet when fully ripe. Commercially they are not important. These latter subvarieties occasionally show the navel cicatrix.

There are many other subvarieties of the sweet oranges, and any who are desirous of studying further into the subject are recommended to

secure "Citrus Fruits and Their Culture," by H. Harold Hume, published by the Orange-Judd Company.

### **Citrus nobilis** Lour.

The Mandarin oranges, which include the dancy tangerine (Fig. 63), are very peculiar. The trees are small, the foliage dense, the branches with small, sharp spines, leaves small with short petioles, slightly winged, and the fruit, usually reddish orange, very flat with the rind loose from the pulp so that it can be readily separated, while the nine

FIG. 64.—Pomelo tree in fruit.
(After Lelong.)

to fifteen sections of the pulp separate very easily the one from the other. Except for curiosity, these Mandarin oranges would have little to recommend them, as the pulp is less melting than that of the sweet oranges and the juice is often unpleasantly tart. I think the pulp usually lacks flavor. Hume gives ten varieties of the Mandarins; one other of these, the Satsuma, has been planted not a little in California. From its deep color, pleasing pulp and absence of rag, the dancy tangerine is interesting and desirable for show. While these sell well, ofttimes, I think no one setting a commercial orchard would think now of using these trees.

**Citrus decumana** Linn.

The pomelo, or grapefruit, and shaddock are distinguished by the large size of both fruit and tree. The fruit of the pomelo is usually in large clusters (Fig. 64), hence the name grapefruit. The tree may reach one and one half feet in diameter and forty feet in height. The petioles

FIG. 65—The shaddock (*Citrus decumana.*) Reduced. (After Lelong.)

of the leaves are broadly winged. The large fruit is greatly prized by many for the morning meal. Many contend that the Florida pomelo is superior to that of California, while others say emphatically "no." The fruit is very juicy, exceptionally flavored and is slightly bitter, which makes it more toothsome to many persons. In California it is a summer fruit, in Florida a winter and spring fruit.

Hume gives sixteen varieties, only two of which, I think, are much grown in California. These are the Triumph and Marsh's Seedless. I have them both, and we prize them greatly. Except for the presence of seeds, I should give the Triumph the preference. I believe that in the near future the pomelo will be one of our standard fruits, which will be grown at a substantial profit. It has been claimed that pomelo seedlings are deep-rooted and so superior. This claim lacks proof, however. The large size of the seeds possibly recommends them.

The shaddock (Fig. 65) is a great, over grown variety, bitter and of no commercial importance. The fruit is a huge jumbo of citrus fruits. It is curiously interesting, and the tree has value for ornamental purposes.

**Citrus japonica** Thumb.

The kumquat is, like the Mandarin, a shrub from four to ten feet high, with branches that bear small thorns, or they may be thornless. The fruit is small, often in clusters. It is relished and prized for the table because of its sweet edible pulp and fine appearance. Except for decorative purposes, however, it is of slight importance. Its deep green foliage and small size make it very desirable for pot culture.

**Citrus medica** Linn.

This species includes citron, lemon and lime. We find here both shrubs and rather small trees; though unpruned, they may reach goodly proportions, of spreading form, foliage light green, flowers tinged with red, fruits spherical or oblong, often mammalated.

Variety **genuiana** Linn. (Citron.)

The citron (Fig. 66) is one of the oldest of fruits, dating back to very ancient times. The trees are about the size of the kumquat; the branches are scraggly and bear thorns; the leaves are very long and the fruit large, bitter, unappetizing, with a very rough rind. It is of principal importance in that the rind when candied is used in pastries and confections. It is very little grown either in Florida or in California and is especially sensitive to cold. It could doubtless be grown in favored localities in California and Florida, but it is not likely to become of any commercial importance for long years, for the cheaper labor of Europe would make it an unprofitable crop in our country.

Variety **limon** Linn.

The lemon is a small spreading tree with foliage light green, leaves crenate or serrate, with twigs often quite thorny; fruits spherical to oval or oblong, usually mammalate; the rind is thin and smooth. The tree is a perpetual bloomer, so that fruit in all stages of development

FIG. 66.—The citron. Reduced one third. (After Lelong.)

may be found at all seasons of the year. A well cared for grove will furnish fruit once a month. The lemon is more prolific than the orange, although the lemon is less tender to cold than is the citron, yet it is more susceptible than is either the pomelo or the orange. It is easily propagated from seeds or cuttings, but is best secured by budding on strong stock, either of sweet or sour orange, which is necessary to secure the improved varieties. Sour stock is now in the ascendancy in both Europe and America. It is more than probable that by using selected buds exclusively very superior trees could be secured.

Some years since a hard freeze in some sections not only injured the fruit, but also the trees not a little. This was a severe setback to lemon culture and many groves were budded to Valencia oranges. Soon lemons advanced in price and now the lemon orchard is as profitable as the orange, or indeed, as any other of our common fruits. Mr. C. C. Teague of Santa Paula gives the following from his large experience: "For successful and profitable lemon growing there are five great essentials—climate, proper soil, abundance of water for irrigation, root-stocks suited to the particular soil, and a thorough knowledge of the business of lemon growing. A most thorough and exhaustive investigation by the Citrus Protective League of California of the cost of producing lemons in California has shown that it is about one dollar and a quarter per box, or one and a half cents per pound greater than it is in Italy or Sicily, when the cheaper labor and cheaper transportation abroad are considered as factors in this cost. It is this difference in cost of production between the foreign and domestic lemon that justifies and makes necessary the present duty of one and a half cents per pound."

Of the many varieties of lemons only three, the Lisbon, Eureka, and Villa Franca, have been much planted in California. The first two are now the favorites, and no others are desired by our most successful growers.

### The Lisbon.

This beautiful fruit, from its elongated form, smooth peel, fine grain, ample juice, few seed and great prolificness, is a deserved favorite with lemon growers. It is a good keeper. The tree has, however, one decided drawback, its strong thorns. It is also objected that it is rather too

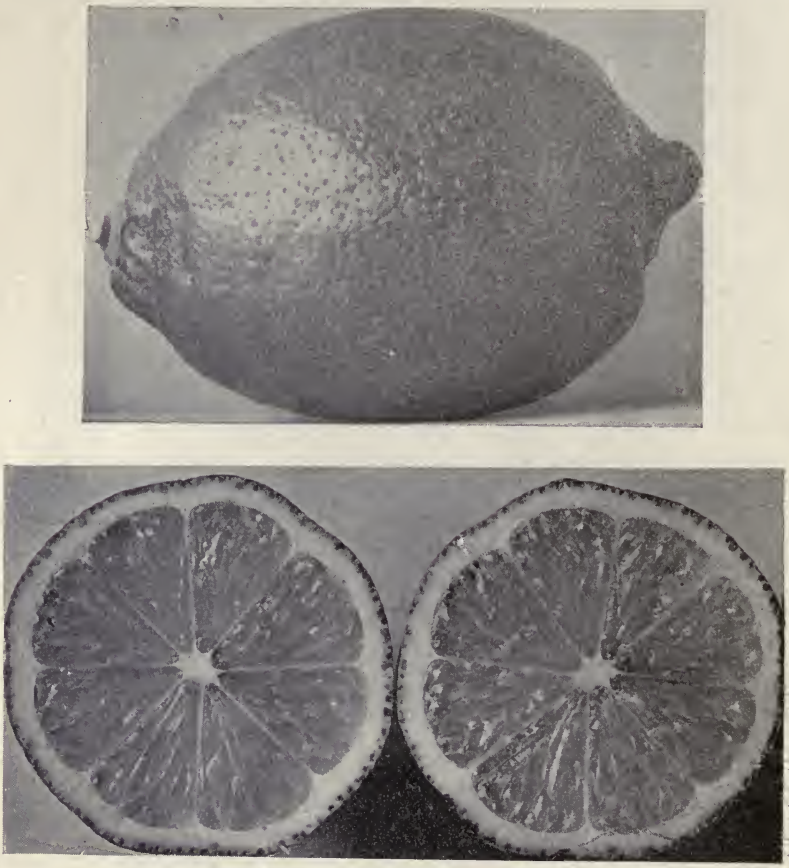

FIG. 67.—The Lisbon lemon. Natural size. (After Lelong.)

shy of summer fruit. Its beauty, however, will always commend it. The Lisbon is naturally a much larger and more thrifty tree than is the Eureka, and in the orchard they are usually set further apart. It grows very compact when but moderately pruned, yet produces a very large proportion of its fruit on the inside twigs and branches, more so than the Eureka.

### The Eureka.

The Eureka, like the Lisbon, is of medium size and also possessed of a smooth, glossy rind, though not the equal of the Lisbon in this respect. The juice is a pleasant acid; it is almost seedles, and it is a good shipper. The tree is a prolific bearer of summer fruit. Its tendency to bear on

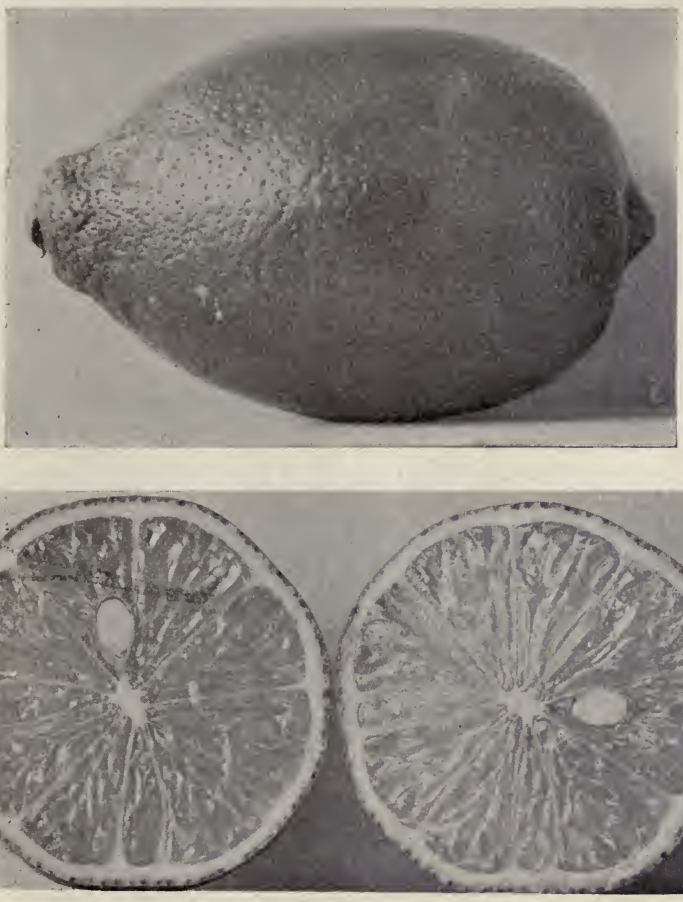

Fig. 68.—Eureka lemon. Natural size. (After Lelong.)

the extreme ends of the limbs is unfortunate, but can be remedied by proper pruning. The fruit is superior in sizing up while still green. The Eureka now leads in popularity in this State. The fact of its being thornless is greatly in its favor.

### Variety **Acida** Hook **or Limetta.** (Lime.)

This very spinous shrub might be considered a miniature lemon, though the juice has a peculiar flavor of its own. The lime lacks

the size and excellence of the lemon, yet when at its best it is no mean fruit. The stem is winged but not as broadly as is the sweet orange and pomelo. The pulp is very sour and has a tinge of bitter which pleases the taste of many. Limeade, with many, is a favorite beverage. The lime has escaped from cultivation in Florida and the West Indies and has run wild. Some varieties lack not for size and some have less pronounced thorns and a less number of seeds. At the Oroville Show a year ago I saw very large limes that were apparently seedless. Of the several varieties the Imperial, Mexican and Tahiti are praised. While the lime bears severe pruning and can be fashioned into a hedge, it will hardly meet the competition of the lemon and will be but little grown in California.

## CITRUS BY-PRODUCTS.

In Sicily the inferior and injured lemons, and to a less degree the oranges, are used for by-products. In case there is a great demand for fruit, the best of this inferior fruit is often diverted to the markets.

### Citrate of Lime.

Citrate of lime is one of the most important of these by-products. The concentrated lemon juice is pressed from the lemon, warmed, filtered, then heated nearly to the boiling point, when finely powdered chalk is gradually added, being constantly stirred, and when effervescence has ceased we have citrate of lime as the result. By adding dilute sulphuric acid to this salt a chemical change produces gypsum (sulphate of lime) and citric acid. The process of this manufacture is simple and the necessary equipment limited and cheap. There is no reason why the growers might not produce this product, except that possibly it would not pay.

### Concentrated Lime Juice.

Lemon juice, as it is pressed from the fruit, is a valued article of commerce. By boiling carefully it is concentrated and is then ready to ship. Only inferior fruit is used for this purpose, especially that which is punctured or bruised. Orange juice or orangeade is also a valuable product.

### Oil of Lemons.

This essence consists of spirits of wine to which oil from the oil cells of the lemon peel is added. The fresh peel is soaked, then pressed against a sponge, which absorbs the oil. Only inferior fruit is used, though it must be fresh and sound.

### Salted Lemons.

Inferior but sound fruit is often shiped as a salted product. The lemons are halved and placed in a salt brine for ten days and then shipped in casks, usually to Leghorn, Tuscany. This salted material is freshened by being placed in water, when it is ready to use for candied peel.

### Candied Lemon Peel.

Leghorn, Tuscany, is the great manufacturing center for candied lemon and citron peel. This is an important product, shipped to many parts of the world. The rind is freed from the pulp, freshened in water and then placed in a weak solution of sugar, which is gradually made stronger, and after several days it becomes saturated with the sugar. A slight fermentation is said to improve the product. At last it is boiled in a concentrated solution of sugar, after which it is dried and coated with crystals of sugar by slow boiling in a very strong solution.

In Italy, where labor is cheap and where everything must be utilized, these citrus by-products are of much importance. It is necessary there that nothing be lost. One third of the Italian lemons are converted into by-products. These industries have further service, as the culls are disposed of and injury of the market is not caused by their sale. At present these by-products are of small importance in America, but we may hope that the inventive genius of our people may bring about a change in the not distant future. The U. S. Department of Agriculture is now experimenting regarding the practicability of our using our culls profitably in the production of citrus by-products. We all hope that success will crown their efforts.

## THE GOPHER.

(Thomomys sps.)

Citrus and other fruit trees are often partially or completely girdled by the pocket gopher. I have seen great havoc wrought by this destructive rodent. The wise orchardist will be vigilant to protect against this destructive mammal. Traps set in their run-ways, or raisins or bits of tender orange twigs with strychnine inserted in a slit, placed in their run-ways, cause their speedy death.

# FARMERS' CLUBS.

My friend, Mr. J. H. Reed, whose suggestions are always to be considered, urges me to append to my booklet a word of advice as to clubs and co-operative associations. It is certainly a wise suggestion.

No one can doubt the value of our Farmers' Institutes. Michigan originated this "University Extension Work" in 1875. I was one of the lecturers at the first institute, and have been engaged as director most of the time from that day until now. In Michigan I inaugurated the movement to form a monthly club at each institute. Michigan, I think, excels to-day in the number of such clubs. As conductor of farmers' institutes in southern California for twelve years, I emphasized the value of such organizations and aided in organizing over forty-five. Who can doubt the wisdom of such action? This virtually gives each locality an institute each month. Such clubs have been of immense value to many sections of our country.

### Requisites for a Successful Club.

A wide-awake club requires enthusiastic officers, whose devotion will permit no abatement of effort to make the club first best. Secondly, a meaty programme at each session is a prime necessity. Thirdly, we must have committees that will make a thorough study of some phase of ranch work, each reporting at least once a year. This will give the club dignity and influence. I would urge, in addition, ceaseless effort to make the social atmosphere as fine and bracing as is possible.

I will outline the principal features of the Claremont Pomological Club, of which I was president from 1894 to 1912. It is a strong club and has done exceptionally good work.

Besides the usual officers who perform the duties common to such officials, there are committees on insects, cultivation, irrigation, fertilization, roads, household economy, street trees, decorative planting, and good of the club. The club meets one day of each month from September to June, inclusive. In June and September picnics are enjoyed, always with a first-class dinner and programme, when all are cordially invited to attend. The attendance usually runs up into the hundreds. July and August are vacation months. Thirty-three families are the limit of membership. There are several applications constantly on the waiting list.

The social status of the club is admirable. The meetings are held and entertainment provided at the homes of the members in succession. The club owns the chairs (seventy-five folding chairs), lapboards, knives, forks, spoons, plates, cups and saucers and tablecloths. There

are usually from eighty to more than a hundred at each meeting. The host may invite at pleasure, and if any member has company from abroad he can take them to the meetings if he informs the host. This would seem a great burden, but as it occurs only once in four years, it is not grevious and once given it ensures thirty-two good times, big eats, and rich mental feasts with no cost or labor.

The above account will make it easy for one to write a constitution and by-laws, under which to organize a successful club.

The Claremont Club founded the local telephone company, with over four thousand phones, helped form the County Insurance Association, which saves immensely to its patrons and who now has over five million dollars in policies. At the time of the forty-five clubs it was their influence that secured for us our excellent fertilizer law in the face of most vehement opposition. May we not hope to rival Michigan with her hundreds of wide-awake clubs? Nothing would foster the fruit interests with more energy and certainty.

## THE CALIFORNIA FRUIT GROWERS' EXCHANGE.

The California Fruit Growers' Exchange represents about sixty-five hundred growers who have organized themselves into one hundred or more local associations. Each association usually owns its own packing-house, where the fruit of the members is assembled, pooled and prepared for market under brands adopted for the different grades by the association. The association usually picks the fruit of the members.

The associations in the different regions combine into one or more district exchanges, which represent the associations in the business operations common to each, and which sell the fruit through the agents of the California Fruit Growers' Exchange, receiving the proceeds therefor through the California Fruit Growers' Exchange, an incorporated agency formed by a representative of each of the seventeen district exchanges. The California Fruit Growers' Exchange acts an as agent in furnishing the facilities through which the fruit is placed in the different markets by the growers through their sub-exchanges and sold, through its own exclusive agents to the trade or by auction, and collects the proceeds and transmits them to the district exchanges, which in turn pay the growers through the local associations.

The central exchange, the district exchange and the association all transact the business for the grower at actual cost. The central exchange through its agents is in daily touch with the markets of America,

thereby enabling it to secure the information through which the sub-exchanges distribute the fruit intelligently. The local exchanges and the associations receive a daily bulletin from the central exchange, which outlines the condition of all the markets the preceding day, states the selling price of all exchange cars, and gives the growers such information as will help them to pack and distribute their fruit to the best advantage.

## THE CITRUS PROTECTIVE LEAGUE OF CALIFORNIA.

The citrus industry of California has formed a voluntary organization, known as the Citrus Protective League, to handle the public policy questions that affect the industry as a whole. This organization represents about ninety per cent of the shippers and shipping organizations in all parts of the State in handling such questions as railroad rates and transportation problems, customs, tariffs, and other governmental relations, state and federal legislation that applies directly to the citrus industry, and all other questions of a general nature that affect the upbuilding of the industry, except the marketing of the fruit.

The league has brought about reductions in the freight and refrigeration rates on citrus fruits, which have saved the producers millions of dollars. It secured through Congress the equalization of the tariff duty between oranges and lemons by securing an increase in the duty on lemons, more nearly equal to the difference in the cost of producing the lemons as compared with the oranges. The league brought about the promulgation of new regulations regarding the determination of decay in imported fruit, thus protecting the California industry against unfair competition; and, in general, has secured the aid of the State and Federal Government in the study of the nutrition troubles, production of citrus by-products, and constructive questions affecting the industry.

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